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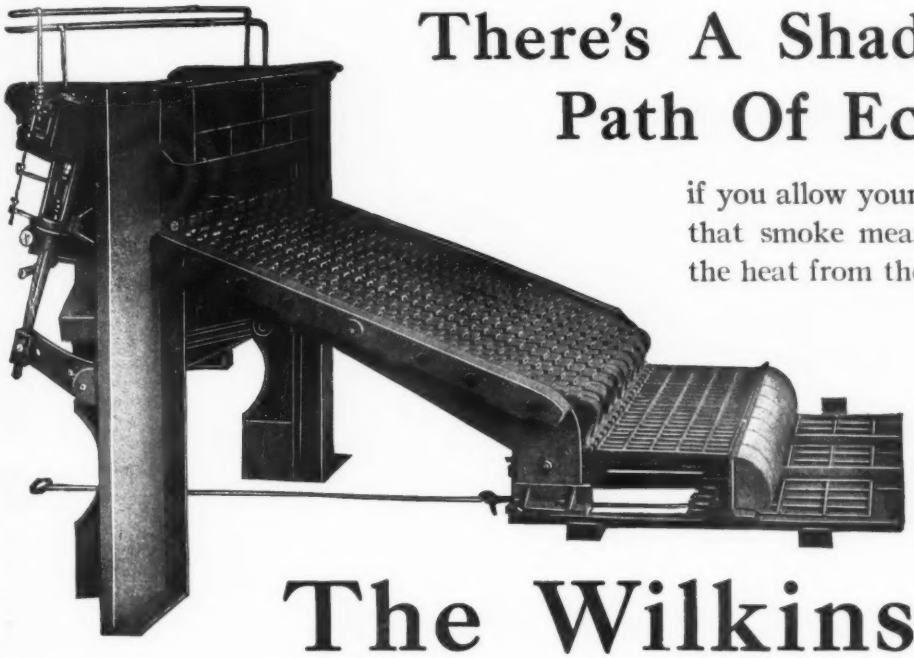
POWER AND THE ENGINEER

ISSUED WEEKLY BY THE HILL PUBLISHING COMPANY, 505 PEARL STREET, NEW YORK.

Vol. 29. Index to Advertisers and Classified Index Following Reading Matter No. 16



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The Wilkinson

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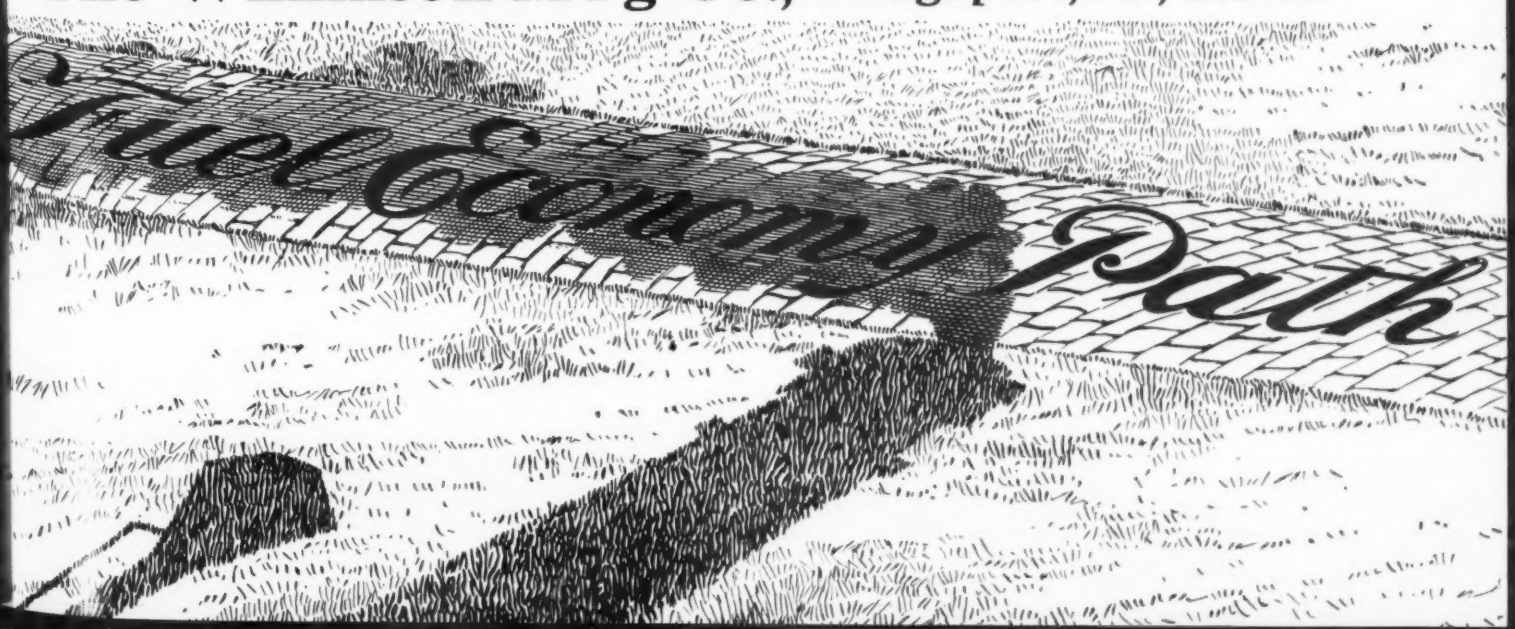

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to convince you that there is scale on your boiler tubes

no matter if you use compounds,
no matter if you purify your feed water,
no matter if you use other mechanical cleaners,

—there's just one way to convince you, and that is to have you run

THE DEAN BOILER TUBE CLEANER

through the tubes. Try it and see for yourself.

We'll loan you one of these tools for a thorough test in one boiler, free of charge. Want to test the efficiency of your compounds? Your purifying system? The mechanical cleaners you now use? The Dean will do it for you. Maybe you're not in a position to purchase the tool now—well try the Dean, anyway, and you'll know where to place your order next time.

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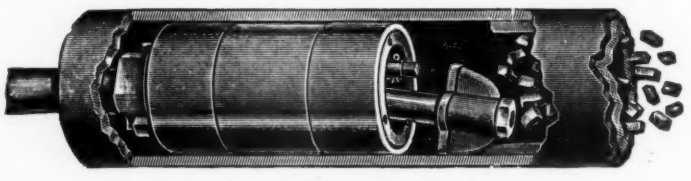
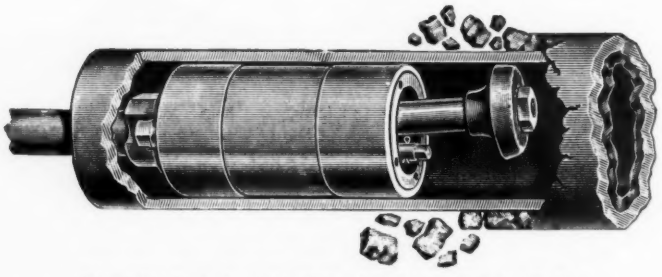
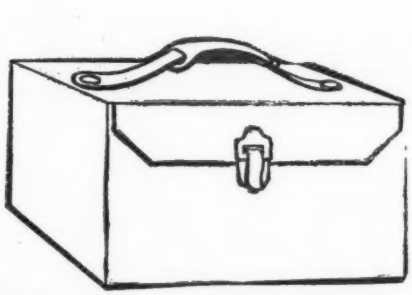
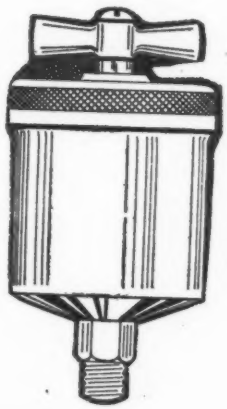


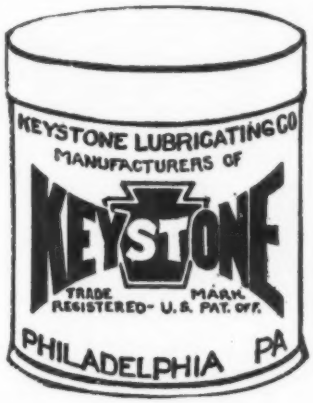
Removing Scale from the Tube of a Water Tube Boiler.



Removing Scale from the Tube of a Return Tubular Boiler.







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Oct. 20-08, Dept. B

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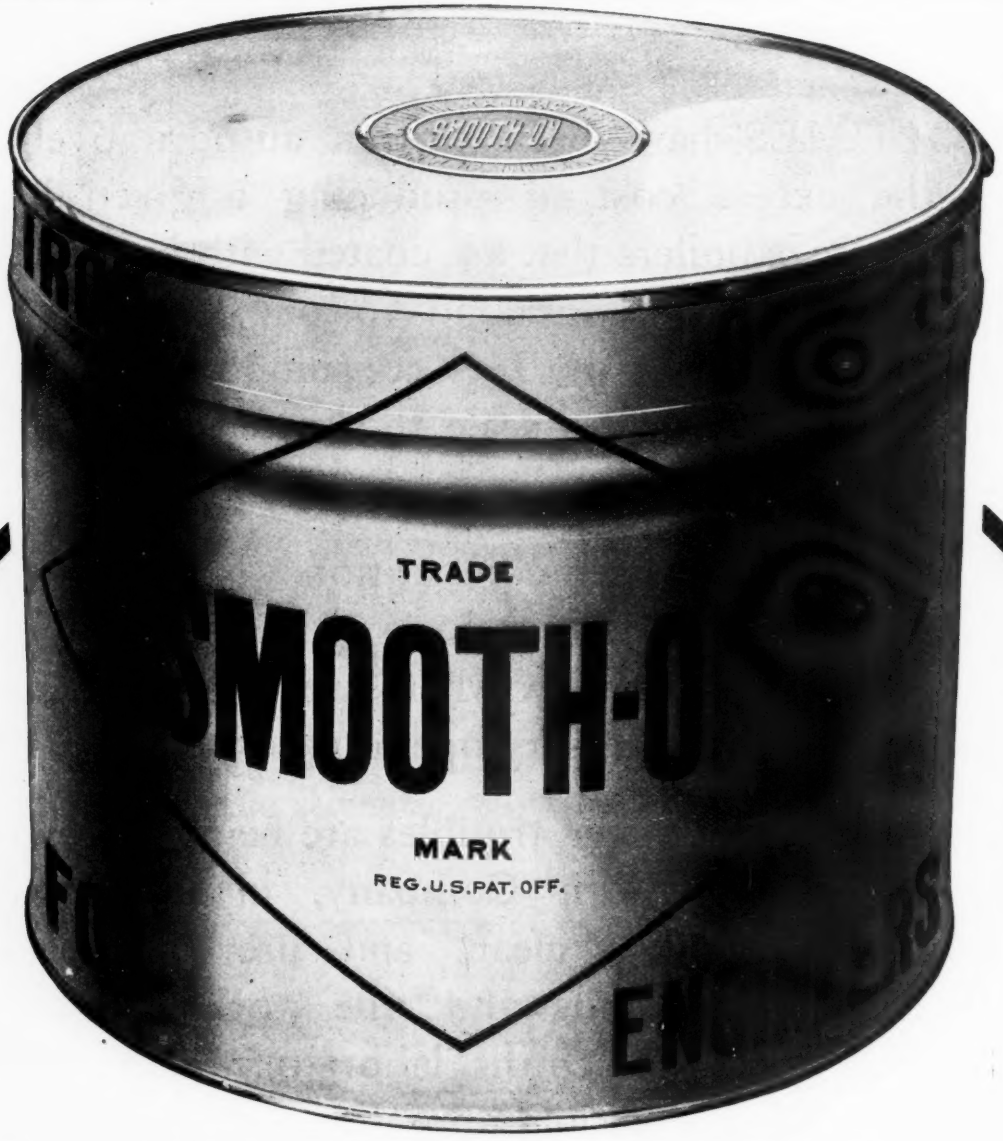

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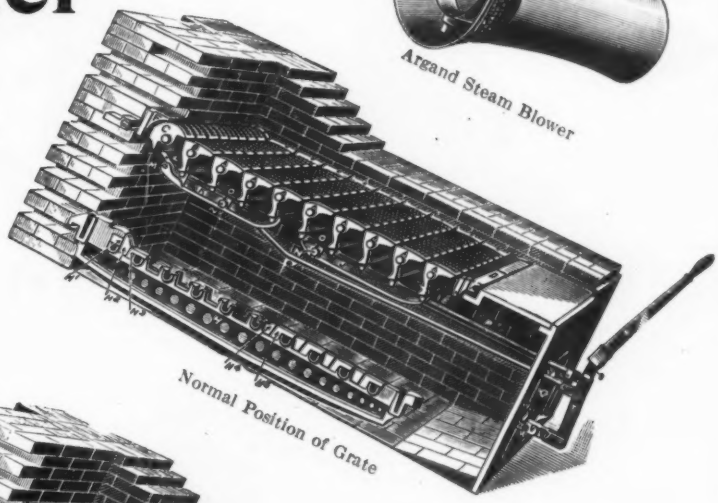
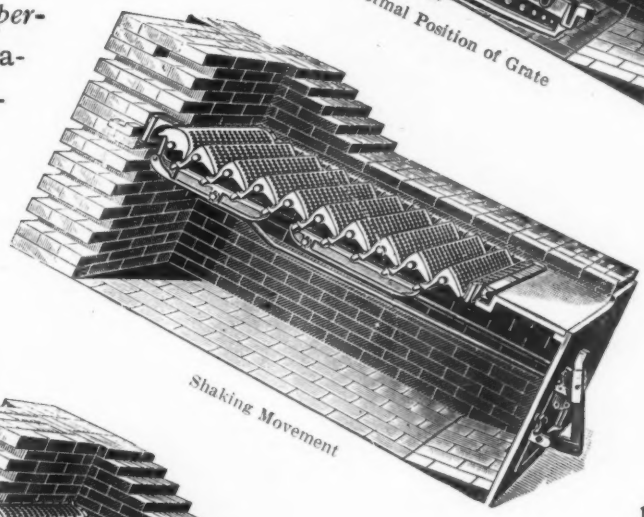


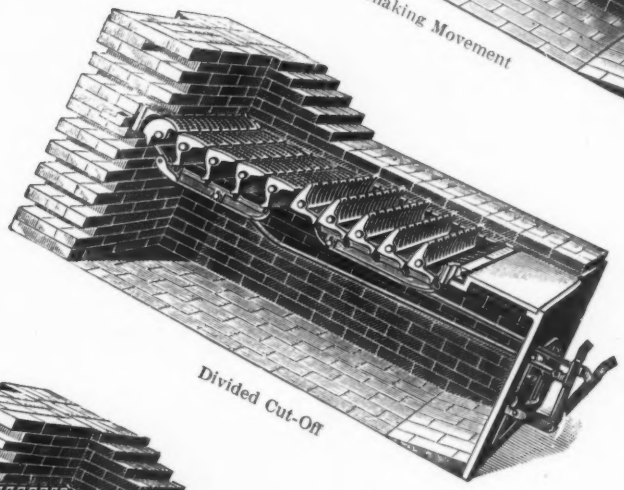
Normal Position of Grate

Together they secure *perfect combustion* of anthracite birdseye, bituminous slack, screenings, duff, coke breeze, etc.

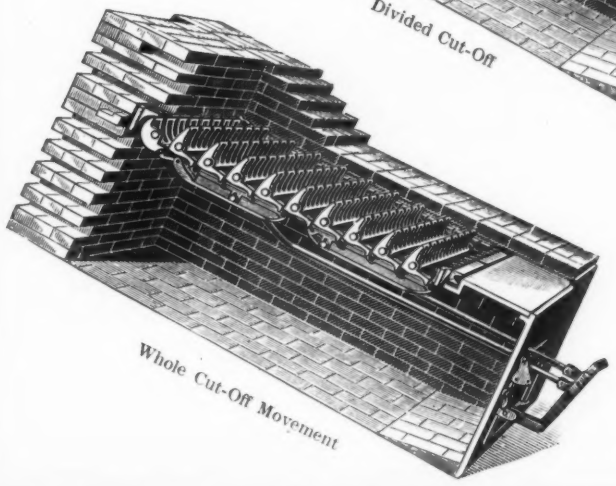


Shaking Movement

Send For Catalog "G"



Divided Cut-Off



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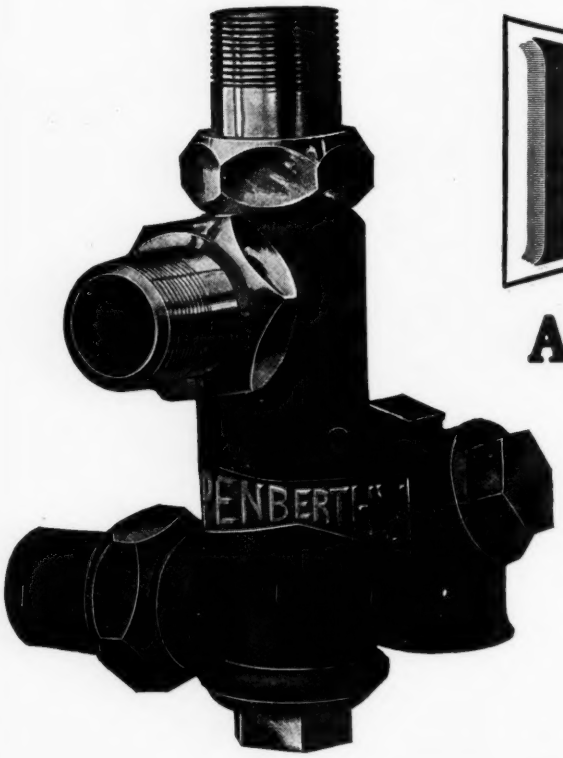

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3rd—It delivers a maximum amount of water with a minimum amount of steam.

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Has no equal in lifting or elevating liquids. Used Exclusively by the leading creameries, tanneries, breweries, brickyards, distilleries and dye houses in the country.

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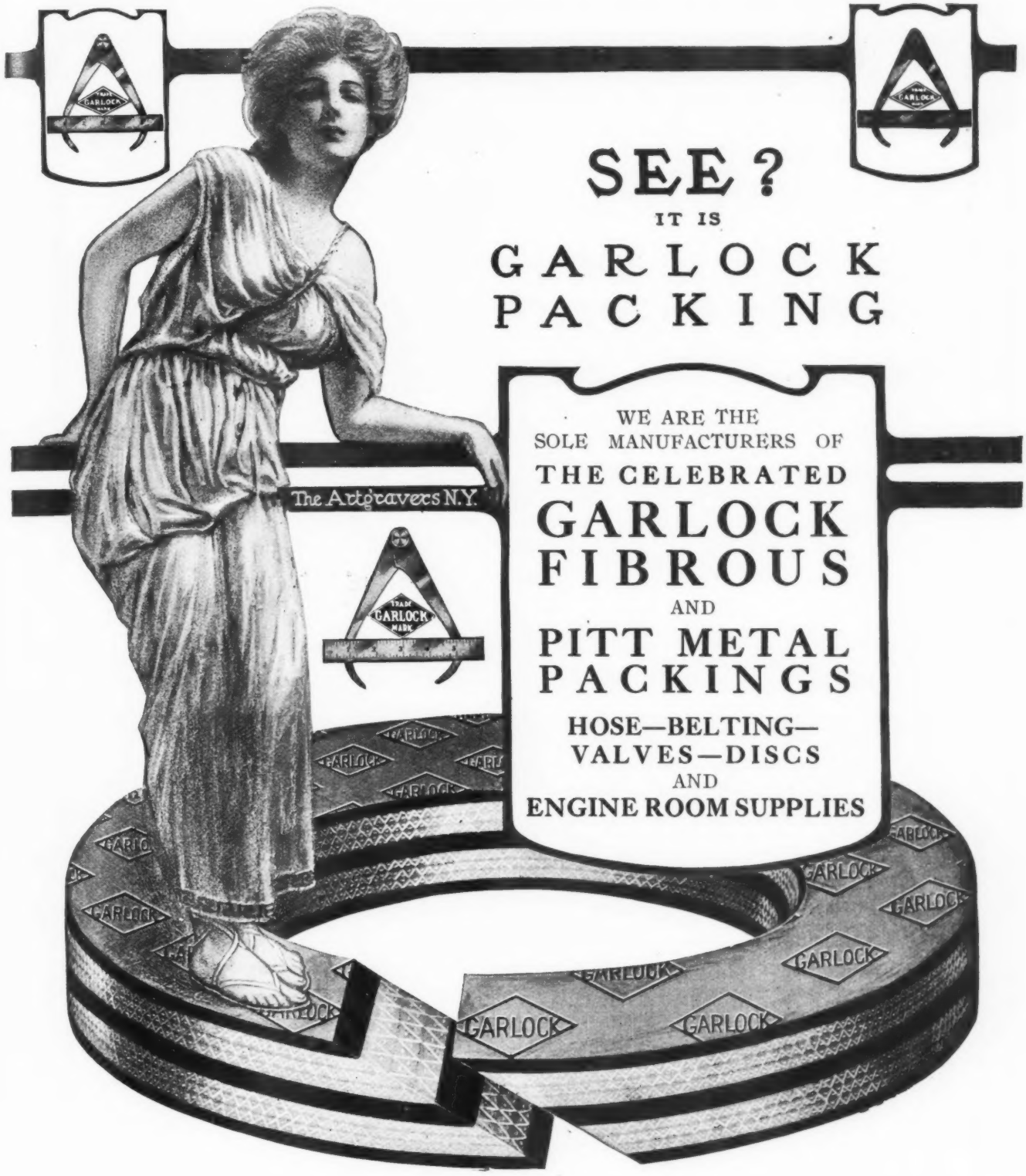

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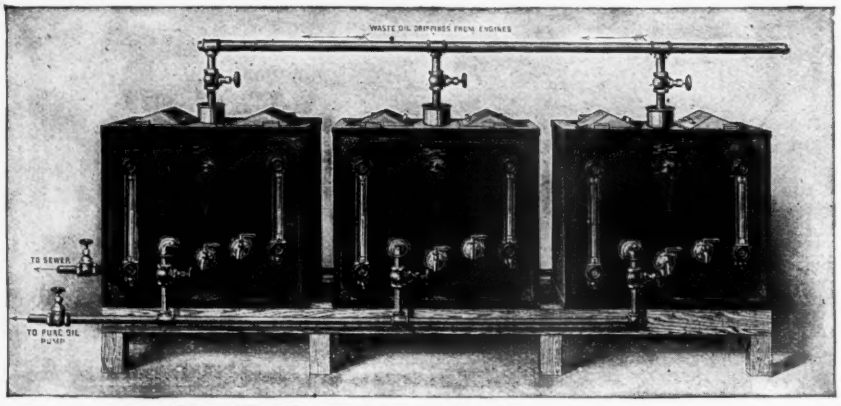

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Largest Manufacturers of Oil Filters in the World.

Design for a 25-Horsepower Gas Producer

Principal Parts of a Producer Plant, Laying Foundation and Erection of the Apparatus, Cost of Fuel, Cost of Plant, How to Start and Operate

BY F. C. TRYON

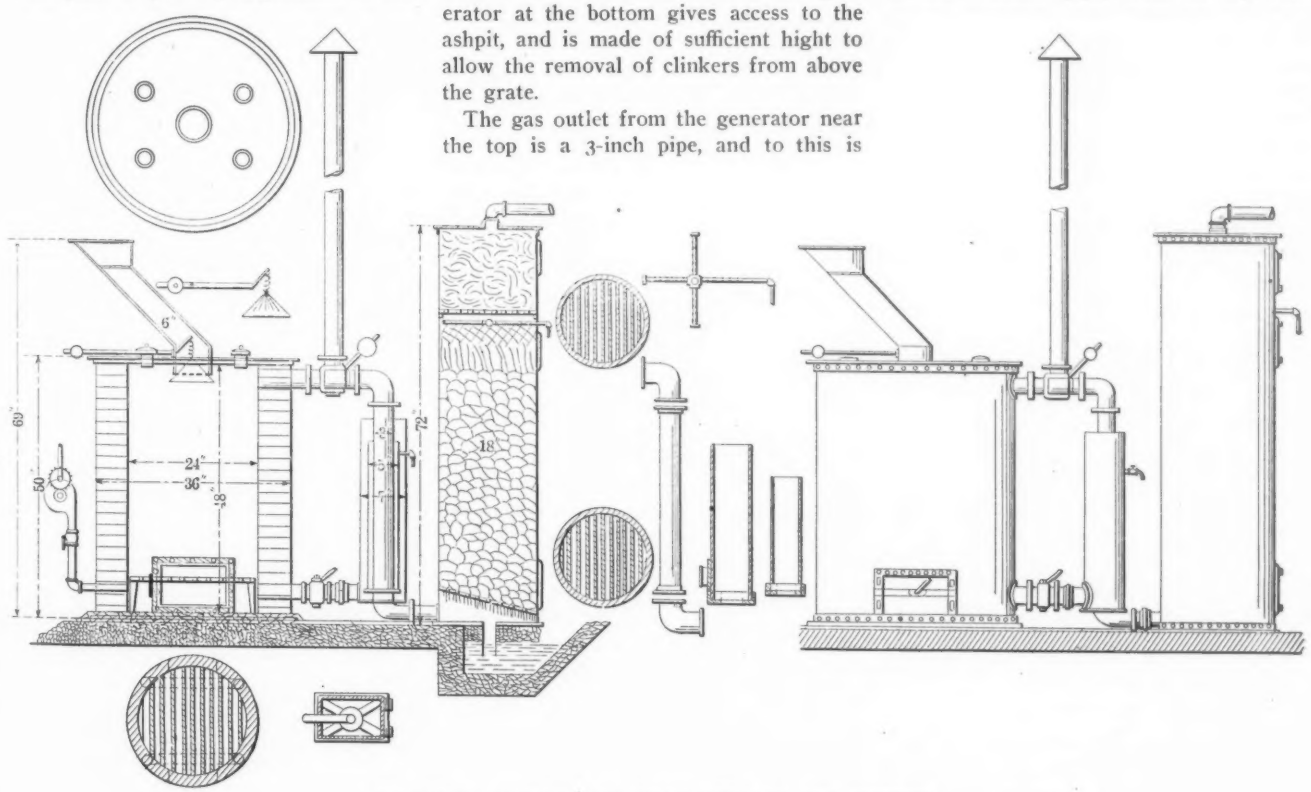
In this article are given instructions and complete specifications of the materials necessary for building a 25-horsepower suction gas-producer plant, the horsepower rating being based on 1¼ pounds of coal per horsepower-hour and 10 pounds of coal per hour per square foot of grate area. All parts are sufficiently heavy to be made air- and gas-tight and strong enough to sustain the loads they have to carry.

Principal Parts of a Producer Plant

The part of primary importance is the gas generator, in this case a steel shell of 36 inches outside diameter and 50 inches high, with a cast-iron double top containing a water space. The top has four poke holes, to be closed with plugs, and a coal-feeding hole in the center, to which are attached a spout and coal magazine with a tight-closing cover, and on the under side is a bell or cone seal to prevent the escape of gas when closed. This bell is held in place by a lever and weight, and when opened or dropped down will act as a distributor to scatter the coals, as they fall into the producer, over the entire fuel bed. The producer has no bottom, but has a ring of angle iron around the shell. This is imbedded in a concrete foundation. The grate is of cast iron, made in sections, and is set on andirons, each having four legs 6 inches high resting on the concrete foundation. The grate just fits inside the brick lining. If it should ever be necessary to replace it, a new grate can be dropped into place by removing the top of the generator. A door in the side of the generator at the bottom gives access to the ashpit, and is made of sufficient hight to allow the removal of clinkers from above the grate.

The gas outlet from the generator near the top is a 3-inch pipe, and to this is connected a two-way valve, one side opening to the pipe leading to the scrubber and the other to a waste pipe leading to atmosphere. When one is opened, the other is always closed. This is in accordance with the requirements of the National Board of Fire Underwriters. The 3-inch pipe is connected to the two-way valve by an elbow and pipe leading down nearly to the foundation. This pipe passes through a 5-inch pipe, 20 inches long, with a head on the bottom end fitting water-tight around the 3-inch pipe and having water connection with the double top of the producer. Over this 5-inch pipe is another pipe of 7-inch diameter, 36 inches long, also closed at the bottom end air-tight around the 3-inch pipe. From the side of the 7-inch pipe near its bottom end another 3-inch pipe projects inside the producer shell and lining immediately under the grate. The upper ends of both the 5-inch and the 7-inch pipes are open to atmosphere. The inner or 5-inch pipe is kept supplied with water, up to the overflow pipe, from its top connection to the producer. This water surrounds the 3-inch pipe carrying the hot gas from the generator to the scrubber, so that the water is vaporized, and the air, in passing down inside the 7-inch pipe surrounding the pipe containing the water, absorbs this vapor and carries it into the generator under the grate and up through the bed of fuel.

Under the pipes above described is connected a 3-inch elbow, and to this a short nipple connecting to the scrubber, which is a cylindrical steel shell 18 inches in



SECTIONAL, EXTERIOR AND DETAIL VIEWS OF THE PRODUCER

diameter and 72 inches high. This scrubber has a cast-iron top and bottom, and out of the center of the top is a 2-inch gas connection leading to the engine. Into the bottom is screwed a 2-inch nipple 6 inches long, which projects into a small pit in the foundation about 6 inches wide and long enough to extend about 6 inches beyond the shell of the scrubber. From this pit a 1-inch overflow pipe, imbedded in the foundation, carries the water from the scrubber to the sewer or waste.

Inside of the scrubber and near its bottom is placed a heavy, woven-wire tray, set on a slant, its side opposite the gas inlet coming near the bottom while immediately over the gas inlet it is about 6 inches high. There is a door or manhole opening in the side of the scrubber near the bottom and at the low side of the tray, and another opening 4 feet above this. Just under a second tray, which is set horizontally on brackets, another manhole near the top provides an opening above the second tray. Above the lower tray the space is filled up to the second opening with rounded, smooth stones about the size of hen eggs, and above the second tray the space is filled with excelsior that has been dipped in any cheap crude or machinery oil, but not kerosene.

Just under the upper tray in the scrubber an opening gives access to the ¾-inch sprinkler pipe, which is made up of three pieces of ¾-inch pipe 8 inches long, with a cap screwed on one end and the other end threaded, and one piece of ¾-inch pipe threaded on the two ends and 10 inches long. Each of these four pipes is drilled with holes 1/16 inch in diameter and 1 inch apart. The 10-inch pipe has the same number of holes as the 8-inch pieces, but the balance of the pipe projects outside the scrubber walls for connection to the water service. The pipes are all screwed into a cross placed at the center of the scrubber. To clean this sprinkler, unscrew the 10-inch pipe projecting outside the scrubber and remove the remainder of the cross through the manhole opening just below its location.

Laying the Foundation

Prepare a concrete foundation 5 feet wide, 8 feet long and 6 inches deep, except under the scrubber, where it should be 18 inches deep and 2 feet in diameter. In the deep part of the foundation leave a trench 12 inches deep, with the top dimensions 6 inches wide and 20 inches long, the bottom 6 inches wide and 12 inches long, and one end sloping up to the surface of the foundation. In the foundation lay a 1-inch pipe leading from one side of the trench 2 inches below the surface of the foundation to the sewer. When the scrubber is set on this foundation, the 2-inch pipe projecting from the bottom will dip into this pit, and the sloping end of the pit, extending beyond the bottom of the scrubber, will permit of its being cleaned out occasionally.

Erecting the Plant

This producer gas plant will occupy a floor space 3 feet wide and 6 feet 1 inch long. The hight to the top of the pipe leading to the gas engine will be 78 inches. Erect the generator by setting the shell, with the top removed, 1 foot inside the end of the foundation. This should be done before the concrete is dry, and the shell imbedded to the depth of the angle iron around the bottom. When the concrete is dry, place the firebrick lining around the inside of the shell, laying the brick up close to make sure of the lining being air-tight. Dip the firebrick in a cement grout about as thick as molasses, and quickly lay it in place. Be sure the brick in hand is the right one for the place before dipping it in the cement, so that no change or disturbance shall break the bond when once the brick is placed in position. Cut out and shape the bricks to fit tightly around all openings. Place the 3-inch air-inlet pipe in position just under the grate, with a union on the end projecting outside of the generator for connection to the 7-inch pipe. Build up to the gas-outlet pipe, being sure of tight connections around these pipes. Build up to the top of the generator shell, and after putting in the grate, cover the bricks with cement and imbed the cast-iron cover in this cement, securing a tight fit between the iron casing or shell of the generator and the cast-iron top. Adjust the bell and lever so the bell will be drawn tight before the lever is quite horizontal. Then adjust the weight on the lever so that it will hold the bell tight against the projecting spout connected to the coal hopper. Arrange the coal hopper in place and fasten by bolting securely. Be sure the cover fits tightly and is always closed before raising the lever to allow coal to drop into the generator.

When the generator is in place, fasten the two-way valve to the gas-outlet pipe, so that one of the openings is upward and the other throw of the valve is toward the end farthest from the generator. Screw on the elbow with the opening downward. Next take the long piece of 3-inch pipe, with the two other pipes outside of it, and screw it into the elbow. Bring the opening near the bottom of the 7-inch pipe, fitted with a short nipple and half of a union, opposite the 3-inch pipe projecting from the side of the generator just under the grate, and connect these unions. From the elbow on the bottom end of this cluster of pipes, make the bottom connection to the scrubber. Adjust the trays, fill in the stones and excelsior and connect up the sprinkler and the pipe from the top of the scrubber to the engine.

How to Start and Operate

Open the two-way valve to the waste pipe, and fill the 5-inch pipe surrounding the gas pipe with water to within about 3 inches of the top. Place shavings or paper on the grate, cover with kindling, ignite, and as soon as the kindling is burning, feed in a quantity of wood in small pieces. While this is burning, fill the hopper with pea or nut anthracite, and when the wood has got a good start, lift the lever and let the coal drop into the generator. Always close the cover on the coal hopper before lifting the lever. Close the cock in the air pipe and close the door; then start the hand blower. When the coal has had time to become incandescent, add other hoppers of coal until the fuel bed in the generator is about 3 feet deep. Whenever the blower is stopped for any length of time, the cock in the air pipe should be opened to give a draft to the producer. Turn the water on in the scrubber until it shows in the pit, open the vent or test pipe at the engine and then throw the two-way valve and close the purge so that the gas will pass into the wet scrubber. Turn the hand blower until the gas has driven all the air from the scrubber and the line of pipe to the engine, and be sure that the mixture of gas and air has all been driven from the line before attempting to light the gas. When it is certain that nearly all of the air has been excluded, try the gas at the test pipe. If it ignites and remains burning, it is ready for use in the engine.

The generator can be filled with coal nearly to the top. With a 3-foot depth of bed there will be fuel enough to run a 25-horsepower engine full load for about 18 hours. When the gas engine is in operation and is running well, the fuel bed of the generator should be disturbed as little as possible. It may be necessary once a day to bar down the fire, by inserting the poker, which should be about ¾ inch in diameter and 6 feet long, with a pointed end, into one of the poke holes in the top and jamming it down through the fuel bed. This may be done several times through each of the poke holes, but it had better be thoroughly done only in the morning before filling with coal. If a hole or chimney forms through the fire bed while in operation, use the tamping bar a few times lightly without going through the fire bed, or feed on some fresh coal. The tamping bar is made with a nob on the end. When the producer is shut off or stopped, throw the two-way valve to the waste pipe and close the cock in the air pipe. This shuts off all inlet of air and allows the fire to smolder.

When it is desired to start again, turn the blower until the fire is well enlivened, and then bar down and feed fresh fuel. In cleaning out the ashes, open the door to the ashpit and rake out the ashes immediately on the grate, and any clinkers that may have formed. As soon as fresh fuel or bright coals show on the grate.

stop raking, as a hot fire on the grate will soon burn it clear. Always leave some ashes on the grate, if possible, but remove all ashes from below the grate each day.

Coal Consumption

With a good gas engine designed for producer gas, this producer plant will not consume more than 1¼ pounds of coal per horsepower-hour. If run at the full load of 25 horsepower for 10 hours, the producer will use 310 pounds of coal, and if the coal costs $4 per ton, the fuel expense would amount to 62 cents. The amount of water required for keeping the engine cool and washing the gas would be from 125 to 150 gallons per hour. If water is scarce or expensive, it can be run into cooling tanks with a small pump and used over and over again.

Cost of Plant

A gas producer such as the one described can be built by almost any worker in sheet iron or steel, and should not cost more than $300.

Catechism of Electricity

807. *What effect upon the torque has the strengthening and weakening of a motor's field?*

With a constant armature current, the torque of a motor would be increased by strengthening the field, for the torque is proportional to the product of the armature current, the number of armature conductors and the strength of the field. The stronger field, however, would increase the counter electromotive force for the same speed, and this would reduce the armature current. Under ordinary conditions it is found that if the field of a motor on a constant-potential circuit be strengthened, there will result a more than proportional decrease of armature current. Consequently, within the limits of practical working, the torque of a motor is slightly increased by weakening the field.

808. *How should a shunt-wound motor on a constant-potential circuit be started?*

The motor should have a strong field before current is passed through its armature; otherwise, the low torque will delay acceleration and, consequently, the building up of the counter electromotive force, and the prolonged passage of the heavy starting current might damage the armature winding. To guard still further against an injurious armature current it is customary in starting all but the smallest motors to use a starting rheostat, such as was previously described, connected in series with the armature and the source of supply. In very small motors this precaution is not necessary on account of the comparatively high resistance of their armatures.

809. *What important points should be observed in operating a shunt-wound motor after it is started?*

It sometimes happens, through accident to the generator, that the current supply to a motor is stopped for a time. In such an event, if the motor is left directly connected to the supply circuit, a sufficiently strong current may rush through its armature winding when the generator is again started to damage it. Then, too, should the shunt field circuit of a motor be accidentally opened while the motor is in operation, the counter electromotive force would cease and the full voltage of the circuit would be applied unimpeded to the armature. If the supply circuit were not immediately opened, the winding of the armature would probably be burned. To guard against such accidents, a starting rheostat should be selected which is provided with mechanism that will operate, under the conditions described, to protect the motor.

810. *How should a series-wound motor on a constant-potential circuit be operated?*

A starting rheostat must be connected in series between the machine and the supply circuit to prevent too great a rush of current in starting. The series-wound motor on a constant-potential circuit does not have a constant field strength and does not run at constant speed, like a shunt-wound motor. If the load is taken off entirely, its speed may become so high as to cause the armature to destroy itself. The series motor should, therefore, always be started and operated with a considerable load.

811. *For what class of work is a series motor adapted?*

It is suitable only for railway, pump, fan, or other work where variable speed is desired and where there is no danger of the load being removed or a belt slipping off. It is also used where the potential of the supply circuit is subject to large and sudden drops.

812. *How should a constant-potential motor be stopped?*

The resistance in the starting rheostat connected in the armature circuit should be cut out. If, however, there is a switch which short-circuits the starting resistance after the motor is in operation it should first be opened, after which the starting resistance may be cut out as before. In the case of either a separately excited or a shunt-wound motor, care should be taken never to open the field circuit before opening that of the armature, as the low counter electromotive force would allow the passage of a dangerously high current through the winding of the armature.

Constant-current Motors

813. *How are constant-current motors used?*

Very few are in use, because constant-potential motors are so much more satisfactory. Constant-current motors are usually series-wound and operated on an arc-light circuit, which is the only kind of constant-current circuit in this country. No starting rheostat is required, because the current through the motor cannot be greater at the start than when the motor is running regularly, the current throughout the whole circuit being kept constant by the dynamo.

814. *What effect has the load of a constant-current motor upon its speed?*

A series-wound constant-current motor increases its speed as the load decreases, and if the load is reduced considerably the speed will reach a dangerous rate. It is for this reason that such a motor cannot be operated without a governor to control its speed.

815. *Cannot a constant-current series-wound motor be made self-regulating?*

No. Since the current is constant in both the field winding and the armature, the torque is constant regardless of speed, and the least reduction in the external load reduces the resistance to the constant torque, allowing the armature to run away. The speed will increase rapidly until the armature bursts from centrifugal force.

816. *What other characteristics have constant-current series-wound motors?*

Weakening the field of a constant-current series motor reduces the power given out, and also reduces the speed if the load is unaltered. The strength of the field may be easily varied by shunting the series field winding with an adjustable resistance. With a load much above normal the series-wound constant-current motor will not start, but if started with slightly less than full load it will race until the losses due to friction and eddy currents increase the load sufficiently to prevent further increase in speed. The armature of a motor working on a constant-current circuit will not run hot when overloaded because the current remains constant, and therefore the heat which it produces remains constant.

817. *How should a constant-current motor be stopped?*

By first "bypassing" or shunting the main circuit around the entire machine, and then entirely disconnecting both of its leads from the supply circuit.

The application of turbo-blowers to blast-furnace work is certainly increasing. Gerald Stoney, in a paper recently presented to the British Association, says that some of these machines have been recently installed for as much as 50,000 cubic feet of air per minute at from 10 to 15 pounds pressure. A very usual size, which is for about 20,000 cubic feet, weighs about 25 tons, while an ordinary reciprocating blower of equal capacity weighs about 450 tons, or about 18 times as much as the turbo-blower.

Graphite weighing 5255 tons, valued at $330,473, was imported into the United States in seven months this year.

Allowing for the Expansion of Steam Pipes

Effects of Temperature Rise; the Strains Set Up; Practice of Offsetting and Use of Expansion Joints; An Argument in Favor of Pipe Bends

BY PROF. WILLIAM D. ENNIS

All metals expand when heated, the amount of expansion depending upon the metal and the amount of heating. The actual amount of expansion is almost directly proportional to the number of degrees the metal is heated, although it varies quite widely with different metals, being exactly twice as much for lead, for example, as it is for gold, and being less for iron than for almost any other metal excepting platinum and iridium. The amount of expansion of a bar of a stated metal may be expressed as the fractional proportion of increase of length for a one-degree rise in temperature. This fractional proportion is called the coefficient of expansion; thus, if a metal increases its linear dimensions by $\frac{1}{200000}$ when heated one degree Fahrenheit, its coefficient of expansion is $\frac{1}{200000}$, or 0.000005.

Of wrought iron the coefficient of expansion is given by Howard as 0.0000067302 per degree Fahrenheit, and that of steel as from 0.0000061700 to 0.0000067561. Cast iron has a coefficient of expansion of from 0.00000556 to 0.00000593. In a steam plant carrying 175 pounds pressure the temperature of the saturated steam is 377 degrees Fahrenheit; at 150 pounds pressure the temperature is 365 degrees; at 125 pounds pressure, 352 degrees; at 100 pounds, 337 degrees; at atmospheric pressure, as in the exhaust piping of non-condensing engines or in low-pressure heating systems, the temperature is 212 degrees; at 26 inches of vacuum the steam temperature is about 126 degrees. Plants using superheated steam may show temperatures up to 800 degrees.

During the life of a plant the usual range of temperatures may be taken to vary from the figures given, as a maximum, down to zero as a minimum. It would probably be unsafe, however, to assume 126 degrees as the maximum temperature on exhaust pipes of condensing engines, since at times these pipes may be subjected to steam at atmospheric pressure. Making this substitution, we have the conditions shown in Table 1.

TABLE 1. LINEAR EXPANSION OF PIPES IN POWER PLANTS.

Pressure of Steam, Lbs. Per Sq.In.	Maximum Range of Temperature, Deg. F.	Material of Pipe.	Expansion per 100 Ft. of Length.
(Superheated)	800	Steel	6.2 inches
175	377	Steel	2.9 inches
150	365	Steel	2.8 inches
125	352	Steel	2.7 inches
100	337	Steel	2.6 inches
0	212	Steel	1.6 inches
0	212	Cast iron	1.5 inches

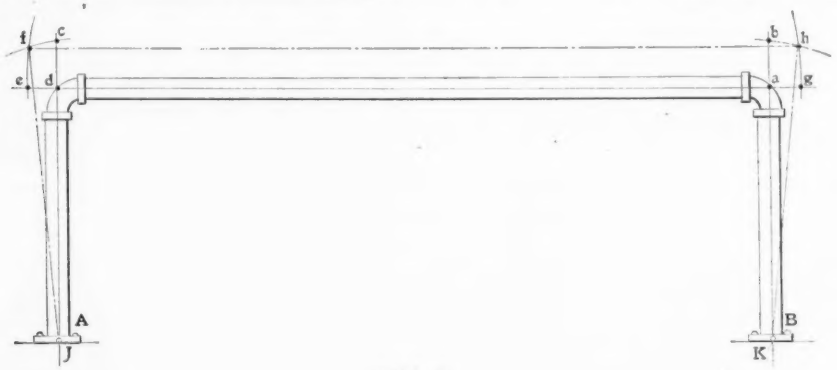


FIG. 1

Expansion Pressure Irresistible

Considering a 12-inch steam pipe 50 feet long, carrying 125 pounds of steam pressure and expanding in consequence of a temperature rise of 350 degrees, this pipe is subjected to two strains. The cross-sectional area of the pipe being 116.54 square inches, the pressure against its ends is

$$116.54 \times 125 = 14{,}568$$

pounds, tending to stretch the pipe. Besides this stress, if the weight of the pipe is 55 pounds per foot, its total weight is 2750 pounds, which is raised in temperature 350 degrees, and as the specific heat of iron is 0.1138, the total heat absorbed by the iron due to its increase in temperature is

$$2750 \times 350 \times 0.1138 = 109{,}500$$

B.t.u. In foot-pounds, this is

$$109{,}500 \times 778 = 85{,}000{,}000.$$

This force is equivalent to the heat energy placed in the steam pipe and manifested in its rise of temperature. If this internal energy could all be transformed into mechanical work acting through a distance equal to the amount that the pipe expands, the pressure that would be exerted in consequence would be equal to 85,000,000 divided by the distance that the pipe moves in feet. This distance is

$$50 \times 350 \times 0.0000067302 = 0.1176$$

feet, which must be divided by 2 to get the average movement of the whole pipe, giving 0.0588. Dividing this into 85,000,000, we have 1,448,000,000 pounds as the pressure that would be exerted. If this force of 85,000,000 foot-pounds, wholly transformed into external work, were made effective, as it would be in the case of warming up the steam-pipe system in 15 minutes, it is equivalent to

$$\frac{85{,}000{,}000}{15 \times 33{,}000} = 172$$

horse-power.

To express this comprehensively, let l = the length of the pipe line, w its weight per foot, t the range of temperature through which it is warmed or cooled, and h the time in which the stated change of temperature occurs. Then the horse-power equivalent of the internal energy is

$$\frac{0.1138 \times 778\, l\, w\, t}{33{,}000\, h}.$$

No fastenings can resist the force of expansion, and it is, therefore, necessary to design pipe lines so that a movement of from 1½ to 6 inches will be possible per 100 feet of length between rigid points.

Simple and Direct Pipe Arrangement

In Fig. 1 is represented in elevation what would appeal to many as the simplest and most direct method of running a steam pipe from a boiler nozzle at A to an engine at B. When steam is turned on the increase in temperature causes the three sections of pipe to expand. The section from J to d, if unaffected by connections, would expand from d to c, the distance being, of course, greatly exaggerated. Similarly, section $K\,a$ would extend upward to b, the flanges A and B being rigidly fixed. Meanwhile, $d\,a$ is also expanding to the length $e\,g$, and the final position of the pipe line will be $J\,f\,h\,K$, as indicated by the heavy dotted lines, the angles, originally $J\,d\,a$ and $K\,a\,d$ being now distorted to the shapes $J\,f\,h$ and $K\,h\,f$.

Fig. 2 shows an enlarged view of the distortion at the point f. The elbow, being of cast iron, will bend very little, so that

the two connecting pipe sections must assume the bent shapes shown. A severe strain is now exerted, tending to break the pipe sections across *A B* and *C D*, to break the fitting across *F E*, and to open the joints *G*, *H* and *J*. The construction is simple, but inadequate.

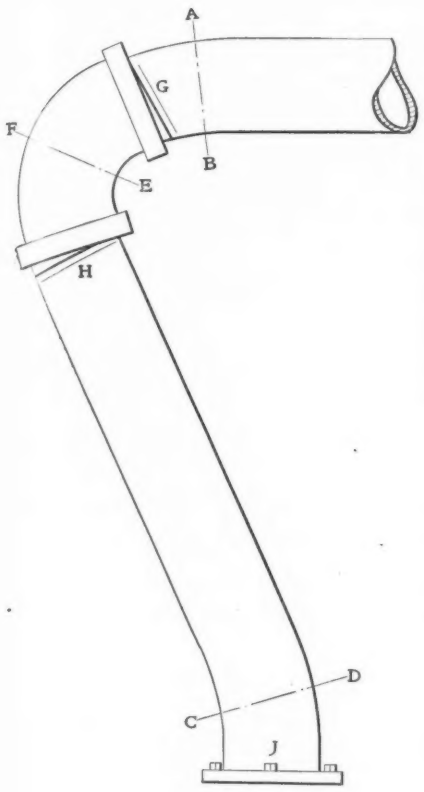


FIG. 2

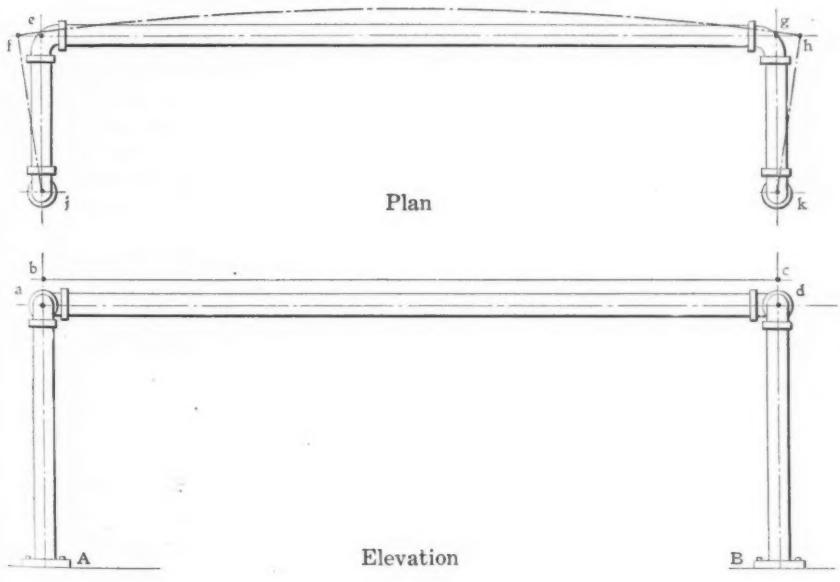


FIG. 3

Offsetting to Provide for Expansion

Fig. 3 shows a construction less simple but more satisfactory. The pipe line is now offset in a horizontal plane, making the apparently unnecessary angles *j e g* and *k g e*, and using, also apparently to no purpose, the lengths of pipe *j e* and *k g* and the two elbows at *e* and *g*. The pipes *A a* and *B d* are, however, now perfectly free to extend upward, raising *j e*, *e g* and *g k* without distortion. When these three expand, the elbows *j* and *k* are free to turn slightly on the threads, so that *k g* may take the position *k h*, and *j e* the position *j f*, without any distortion at *k* or *j*. There will be still some strain at *e* and *g*, in their new position *f* and *h*, and the pipe line will have the form *j f h k*; but as the section *e g* is long, this deformation may result in a flexure, producing the curve *f h* without imposing excessive strain at *f* and *h*. This method of offsetting pipe lines to provide for expansion has been practiced from the early days of steam-heating systems, in which connection it is still in common use. It is also frequently exemplified in power plants of small size or in which space is limited. It is best described by the common rule that *change of plane should accompany changes of direction.*

There are several objections to this form of construction. Pipe systems with it cannot be designed with reference to directness and simplicity alone, nor with reference to convenience of support and suspension nor to the proper disposal of water of condensation. The general arrangement of the lines becomes too largely fixed by the condition of expansion. Too much space is wasted. In large plants, where the pipes are of large size, the expense is considerable. The strongest disadvantage, however, is that this type of design increases the number of joints and as the operating expense of a piping system is proportional to the number of joints, the fewer there are, the better.

The Expansion Joint

The first attempts to avoid the disadvantages of offsetting large pipe lines led to the development of the expansion joint, which in its simplest form consisted of a machined pipe end free to move in and out of a packed gland, as shown in Fig. 4. This device has never been popular, particularly for large work, for which the design was modified as shown in Fig. 5. These joints were made to permit of 6

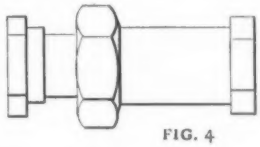


FIG. 4

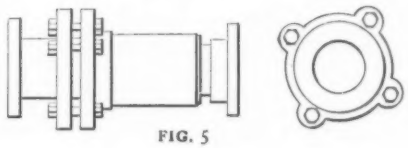


FIG. 5

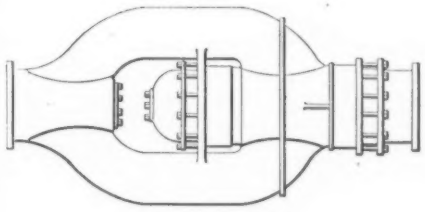


FIG. 6

inches of movement, and their number on long lines was sufficient to make the expense noticeable, while on short lines the number of joints necessary was almost determined by the number of sections of pipe. Another objection is that each expansion joint adds one to the number of pipe joints. The serious difficulty with the packed expansion joint was, however, that it was always leaking steam, required constant attention, and that occasionally the pipe end pulled entirely out of the gland, breaking open the line and interfering with operation. It was always felt to be a makeshift, and was applied more generally on long transmission steam-pipe lines than in power-house work.

Within a comparatively short time there has been evolved from the old stuffing-box type of joint shown in Fig. 5 the more elaborate form of Fig. 6. This has two stuffing-boxes instead of one, the steam dividing between two paths, so as to leave room for the packed gland inside the joint. Danger of pulling apart is still present, two packed joints are harder to keep tight than one, and this form of joint is more expensive than that shown in Fig. 5. Still, where properly erected very good results have in some cases followed the introduction of both forms of packed joint. It should be noted that joints of the types shown in Figs. 4, 5 and 6 require the anchoring of the pipe to avoid danger of pulling apart when the pressure is applied on the line.

Piping specifications frequently contain a clause to the effect that the contractor is to provide for expansion. Often, as well, the supporting of the pipe is described only in the specifications in a gen-

eral clause stipulating that the contractor is to furnish all "necessary" supports. Such clauses shift the responsibility for important features of the design from the engineer to the contractor. They relieve him in many cases of the principal part of his work, and are not fair. A design for piping should show in detail the methods of supporting and anchoring pipe, and the method of providing for expansion. If this part of the work is omitted, then the steamfitter is called upon not merely

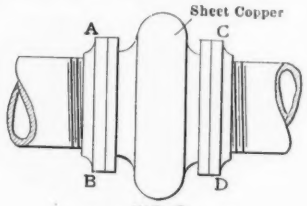


FIG. 7

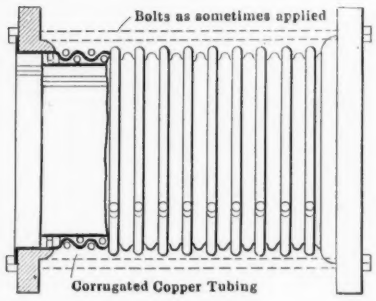


FIG. 8

to design the supports and to provide for expansion, but also to develop a design which will be applicable to rigidly fixed conditions as to the arrangement of the piping. Proper design under such conditions is impracticable even with an expert. The arrangement of the lines, provision for expansion and the method of supporting must be considered together.

The unpopularity of the packed expansion joint has led to the introduction of other forms. One of the simplest is shown in Fig. 7. The semi-circular bulge of sheet copper permits of a limited amount of traverse between the flanges *A B* and *C D*. Although there are no packed joints, this device has several disadvantages. It is, of course, expensive and adds another joint to the pipe line. Its traverse is small and it forms a pocket for water. At the temperature necessary for brazing copper the fibrous nature of that metal is destroyed and a serious reduction of tensile strength and ductility results.

An improved form of copper-expansion joint is shown in Fig. 8. This, originally known as the Wainwright corrugated-copper expansion joint, is free from some of the objections of the forms previously described. It is made up of seamless drawn corrugated-copper tubing which opens and closes like a bellows when the piping contracts or expands. It is made in sizes up to 18 inches, and has been largely used for long-distance transmissions and to some extent in power-house work. It has a fairly long traverse and forms no water pocket. It can scarcely be considered universally applicable in power-plant practice, on account of the expense and of the extra joint in the pipe line. Cases have been found in which the corrugated-copper expansion joint buckled out of shape, so that the design is sometimes modified by having stay-rods run through from flange to flange, these closely fitting against the copper corrugations and holding them in place. Since the coefficients of expansion of copper and bolt iron differ, and the copper is first heated to a higher temperature than the bolts, this construction is open to serious objection.

Fig. 9 illustrates a reversion to the old offsetting system of Fig. 3, with provision for avoiding the buckling of the pipe along *f h*. In Fig. 3, if the elbows *g*, *k*, *e* and *j* are flanged instead of screwed, and if *g* and *k*, *e* and *j* are bolted directly together without the intervening pipes *g k* and *e j*, then in Fig. 9 we have a device for avoiding buckling. In this illustration the joint between an elbow and a tee is illustrated, but the same design would answer equally well for two elbows bolted together. Instead of being connected by bolts through the flanges, each flange is recessed and the recesses ground to form seats for a similarly ground ring. The contact faces are shaped to a radius, so that the two fittings are free to swing independently of each other within the limit imposed by the ½ inch of clearance between the flanges. The joint is made tight by the two 1¼-inch bolts which draw up the heavy end blocks

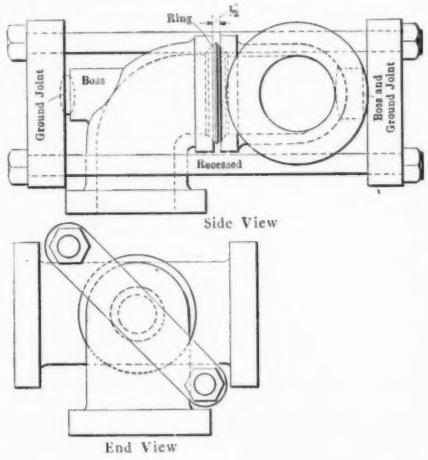


FIG. 9

against bosses cast on the backs of the fittings. Between the blocks and the bosses a similar ground joint is placed. This particular design was largely used in the Schenectady Locomotive Works. In connection with the offset arrangement of piping shown in Fig. 3 it gave perfect freedom from strain on the joints, pipes or fittings, was comparatively inexpensive, and was easily kept tight; but, of course, all of the objections to the offsetting system applied with equal force to that system when supplemented with this type of expansion joint. It was used largely on low-pressure heating lines, especially long lines, but for the reasons already given was not especially suitable for piping in the power house.

An expansion joint similar in principle to the one just described is shown in Fig. 10. This device consists of a pair of socket pieces *B B* provided with pipe flanges and connected by swinging links. A short pipe section *A*, a portion of each

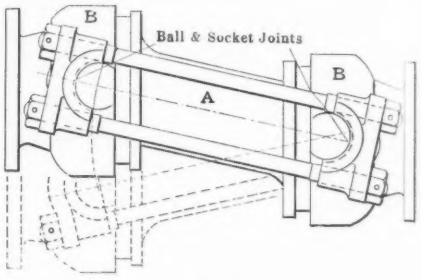


FIG. 10

end of which is machined to a spherical surface connects the two sockets. The ball-and-socket joints thus formed have stuffing-boxes provided to seal any possible leak. These joints are usually made to compensate for elongation equal to the diameter of the pipe.

Pipe Bends are Preferable

We now come to the type of construction generally adopted at present, involving the use of wrought-iron pipe bends. The bend differs from the common cast fitting in being of greater radius, it being impossible to bend wrought-iron pipe with any certainty as to outcome to a shorter radius than six times its diameter. At this radius, standard full-weight pipe can be bent with ease, extra-heavy pipe with rather more difficulty and with poorer results. Bends are obtainable in various shapes, some of which are illustrated in Fig. 11. A longer radius than six times the pipe diameter can, of course, be used, the only limit to the radius being that imposed by the length of the pipe and the angle through which it must bend within that length. Bends far more complicated than any of those shown in Fig. 11 are readily obtainable. The function of the bend, in providing for expansion, is shown in Fig. 12. Here we have the same conditions as in Fig. 1, and if the length between *A* and *B* is not too great, the flexure of the two bends will be sufficient to take care of the elongation between *a* and *b* without imposing excessive strain on the joints of the pipe line. Further, the bends decrease the number of joints in the line, Fig. 1 showing six joints in all, and Fig. 12 only three. The offset construction of Fig. 3 gives ten joints. An expansion joint on Fig. 1 would make the number eight. The bend is superior to all other constructions, with regard to the number of joints. This feature alone is almost an unanswerable argument for

its use in the power plant. The saving in cost of flanges, labor, bolts and gaskets is considerable, and the operating advantages of the greatly decreased number of joints are enormous. No part of the power plant has so low a factor of safety for continuous operation as the pipe joint.

Besides saving joints, the bend decreases the amount of pipe used. If we assume the various bends of Fig. 11 to be shaped to radii equal to 6 *d*, excepting as otherwise noted (*d* being the nominal diameter of the pipe expressed in feet), then, if the tangent ends are made equal to *d*, as indicated, we have the conditions of Table 2.

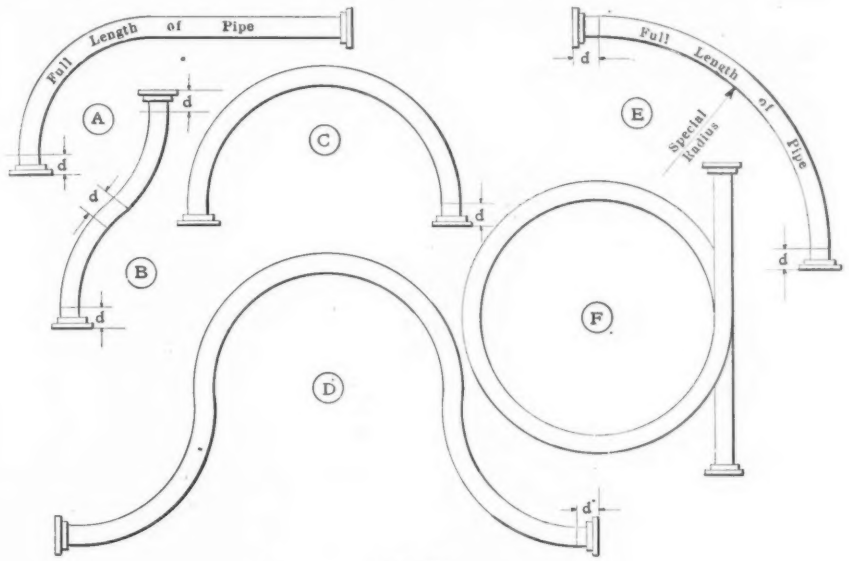


FIG. 11

TABLE 2. SAVING IN PIPE LENGTH DUE TO USE OF BENDS.

No. of Bend.	Kind of Bend.	Length of Pipe in Bend.	Equivalent Length of Straight Pipe.*	Per Cent. of Length of Pipe Saved by Bend.
1	Long	18 ft.	$18 + 2.58\,d$	var.
2	Offset	$12.42\,d$	$12.92\,d$	4
3	U	$20.84\,d$	$26\,d$	20
4	Expansion	$39.68\,d$	$50\,d$	21
5	Square	18 ft.	$22.5\,d$	var.
6	Loop	$39.68\,d$	$50\,d$	21

*To obtain this equivalent length, we have the following relations: In Fig. 13, $H\,D\,B\,E\,F\,G$ is the bend, $H\,D\,C\,B\,E\,J\,F\,G$ the equivalent length of straight pipe, made up with 45-degree elbows. Now $O\,B = 6\,d$ and angle $B\,O\,D = 45$ degrees, hence angle $B\,A\,O = 45$ degrees, and $A\,B = B\,O = 6\,d$. $A\,O = O\,B$ secant 45 degrees $= 6\,d \times 1.4142 = 8.5\,d$. $A\,D = A\,O - 6\,d = 2.5\,d$. $D\,C = A\,D = 2.5\,d$. $A\,C = A\,D$ secant 45 degrees $= 2.5\,d \times 1.4142 = 3.54\,d$. $C\,B = A\,B - A\,C = 6\,d - 3.54\,d = 2.46\,d$. The total length of straight pipe $= H\,D + D\,C + C\,B + B\,E + E\,J + J\,F + F\,G = d + 2.5\,d + 2.46\,d + d + 2.46\,d + 2.5\,d + d = 12.92\,d$.

A variable saving in length of pipe is thus shown, which in nearly all cases is of notable amount. This simplifies the problem of support, decreases strains on joints, decreases the force resulting from vibration and the labor for erection, and is generally desirable. A further, and sometimes greater, saving in weight results from the decreased number of joints.

A saving in the length of pipe results in an operating advantage due to the decreased loss of heat from the steam by friction and radiation. The radiating surface is cut down in proportion to the reduction of lengtn, and the friction losses are less, due to the less length and to the decreased number of short turns. The use of bends tends toward simplicity and directness of construction. The design can be adapted to cramped locations and takes care of expansion without any of the disadvantages of the other methods proposed. The exact amount of flexibility to be relied upon from various forms of bend is a matter of some uncertainty. Distortion beyond a certain stage undoubtedly leads to high strains on the joints. Before reaching excessive strains, however, flexibility at least equal to that given by other methods may be obtained with the proportions of ordinary design. What, then, are the objections to bends? The question of cost suggests no objection. In many, if not most applications, the bend is cheaper than the equivalent run of straight pipe without provision for expansion. This is almost always the case in high-pressure plants in which special and expensive forms of flanged joint are used. The saving in cost of joints then pays for bending the pipe. In many instances on low-pressure work the saving in length of pipe alone is sufficient to pay for bending. Some of the cost of pipe covering is also saved, and the expense of providing supports is decreased.

For some years large pipe bends could be obtained only from a few manufacturers, and some delay was often involved. This condition does not now exist, although it is true that owing to the difficulty of forming bends exactly to dimension, the usual practice in construction is to delay the installation of related parts of the piping system until the bends have been received. This retards erection, but so also does the introduction of modern types of machine-made joint. In both cases, the manifest advantages overweigh the resulting slight delays in erection.

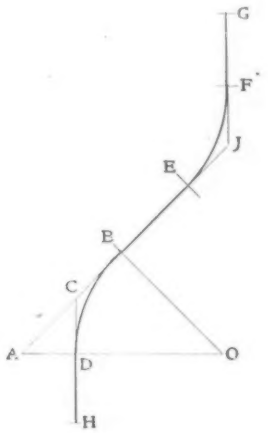


FIG. 13

The only valid objection to the bend arises from its limited applicability. In Fig. 11, bend *A* replaces two straight pipes and an elbow. It is best used when making right-angle turns where a long line extends from one outlet of the elbow. Bend *E* is used where both elbow outlets communicate with long lines of pipe. Each of these bends saves two joints and can be secured in any size. Bend *C* is sometimes used for connecting boilers to the header. It saves four joints over the number necessary with straight pipes and elbows. Since wrought-iron pipe cannot be obtained in lengths of over 20 feet, the length of this bend, 20.84 *d*, Table 2,

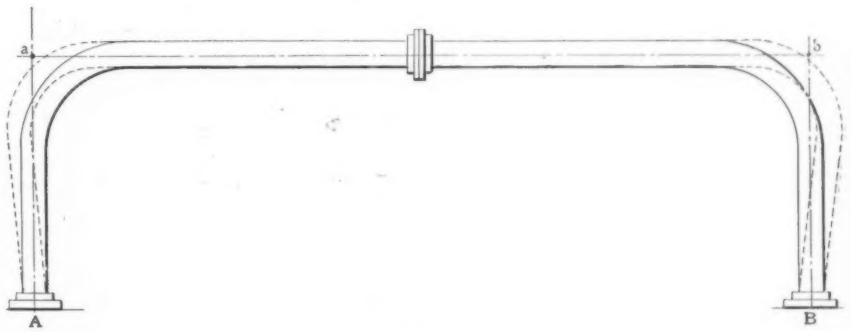


FIG. 12

limits the practicable diameter to 12 inches. This is, however, a liberal limit, since boiler connections are never 12 inches in size. Similarly, the maximum possible diameter of bend *B* is 20 inches. Since this bend saves four joints, and takes care of expansion very nicely in an otherwise critical situation, its limitations with regard to size are unfortunate, particularly as it is most needed on large main lines of pipe. It will not answer to make it in two pieces, placing a flanged joint between, since the strain on this joint would be excessive. Fortunately, however, 20-inch sizes are rather unusual even on main pipes. Bends *D* and *F* are most useful, and are employed on long, straight lines of pipe. They do not save any joints, but are used solely as a means of taking up expansion. Their length limits the diameters to 6 inches, so that they are seldom applicable for the purpose for which their shape particularly fits them. Some designs show these bends made in two pieces, but this is an objectionable construction, imposing severe strains on the joint. For straight runs of pipe larger than 6 inches in size, expansion must, therefore, be taken care of in some other manner; the best device then being the corrugated-copper expansion joint with the traverse sufficiently limited to obviate danger of buckling. This can be avoided, in the majority of cases, by offsetting the pipe at intervals with bends like those shown at *B*, which, however, impose some additional frictional and radiation loss to compensate for the saving in joints.*

Bends for Exhaust and Water Piping

Bends have not come into general use on exhaust pipes, as here the expansion is a much less serious matter. Various incidental advantages secured from the use of bends are a matter of course in ordinary design with exhaust connections. For example, joints are saved and short-radius turns avoided by the general use of special castings. It is an interesting question, however, whether many perplexing variations in vacuum are not due to slight leakages resulting from distortions accompanying expansion, and whether vacuum might not be generally improved by the adoption of bends. Expansion in exhaust pipes is less only in degree; it should be provided for as intelligently and as thoroughly as in live-steam pipe lines.

For water piping in the power plant, the decreased friction and wear alone are sufficient to justify the general use of bends irrespective of the question of expansion.

*Possibly special long lengths of pipe might be welded up to order to form such bends as *D* and *F*. This does not appear to have been done in power-plant installations. There would be some difficulty in shipping such bends.

A Small Traction Plant

By John M. Schwartzell

The Great Falls and Old Dominion Railroad Company has an electric traction plant operating 18 miles of track from Rosslyn, Va., to the Great Falls of the Potomac, and also a bridge line extending across the river from Rosslyn to Washington, D. C. The repair shops, barn and plant are located at Rosslyn. The plant is admirably situated, being located at the foot of a small slope 150 yards from the river, from which feed and condensing water is obtained. Fuel is carried in cars from a nearby spur of the Pennsylvania railroad.

Generating Plant

Entrance to the plant is effected by means of a large doorway at the northwest corner of the building, opening into the engine room. This is a large, airy room, taking up one-half the area of the entire building. The source of power in the plant is a Westinghouse-Parsons

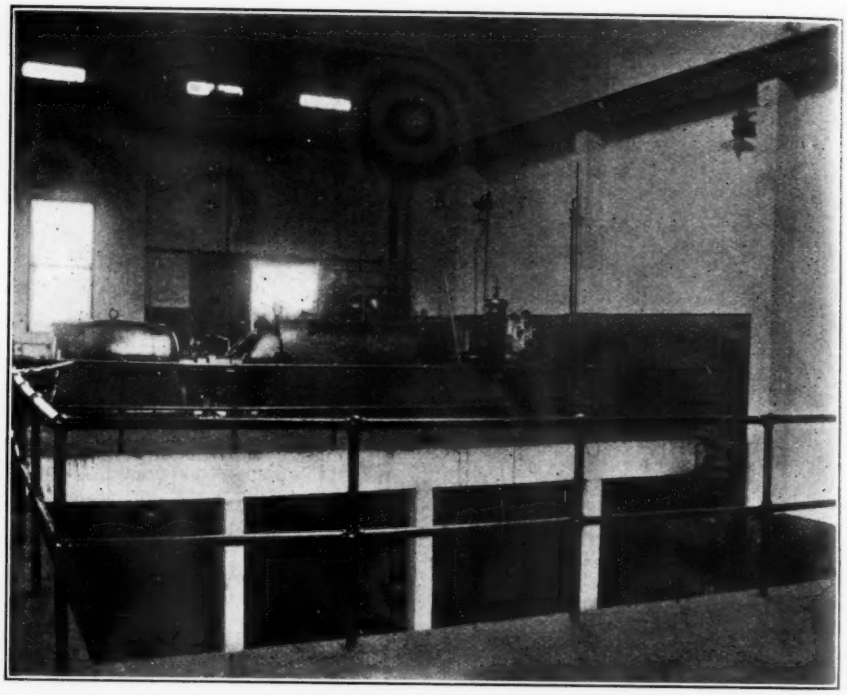


FIG. 1. TURBINE UNIT

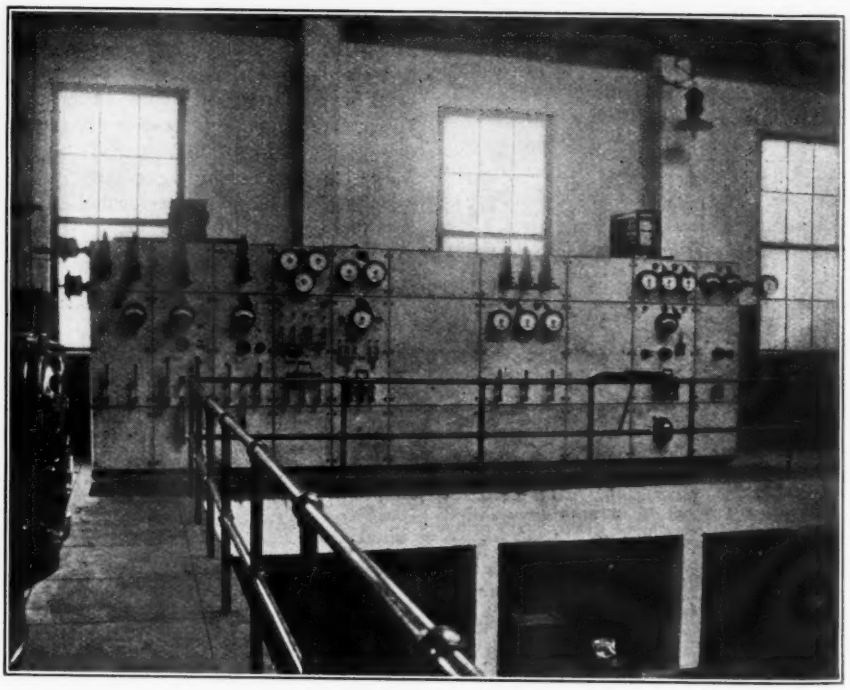


FIG. 2. SWITCHBOARD

steam turbine and 500-kilowatt alternator, driven at a speed of 1500 revolutions per minute, and generating at 400 volts. Nearby is the exciting unit, which comprises a 125-volt direct-connected dynamo operated by a Westinghouse 8x13x8-inch compound automatic steam engine.

Current from the alternator is conveyed to either or both of two rotary converters and to a transformer. One of the two rotaries, a 300-kilowatt machine, is used for the bridge line, which is provided with an all-metal circuit, owing to the fact that the District of Columbia will not allow the use of ground circuits. The other rotary, of 500-kilowatt capacity, delivers direct current at 650 volts, and is used for operating the main line of the road. The current passing to the transformer is stepped up from 400 to 2200 volts, and is conducted to a substation at Ingleside, Va., a small place 10 miles distant. Here it enters another transformer, and the pressure is reduced to 400 volts again. It is then conveyed to a rotary converter, boosted up to 650 volts, direct current, and cut into the main line. This maintains the voltage at the far end of the line.

All circuits of the plant are controlled by a three-panel switchboard equipped entirely with Westinghouse instruments. It contains seven automatic circuit breakers, 20 single-throw knife switches, and the necessary voltmeters and ammeters. The middle panel controls the generator and converters.

Boiler Room

The boiler room, which is half the size of the engine room, contains four Stirling double-header water-tube boilers arranged in a single battery. They are hand-stoked and carry a working pressure of 150 pounds. The boiler feeders and heater, which is of the vertical pattern, are placed at one side of the room a short distance from the boilers. There are two Worthington 6x4x6-inch outside-packed plunger pumps for supplying the boilers and a small Blake 4½x3¾x3-inch for the house supply.

The condensing system was installed by the Alberger Condenser Company, and the centrifugal pump used in connection with the system is operated by a Westinghouse 8½x8-inch steam engine using steam at 100 pounds pressure. Condensing water is obtained from a cistern supplied by water from the river. In case of a fall in the level of the river, the condensing water, after being circulated through the system, may be returned to the cistern and used over and over again, so that it is always possible to operate the condenser even in times of shortage.

A Dangerous Omission

By W. H. Wakeman

In a certain public building a large duplex steam pump was used to maintain the pressure required to operate elevators in the usual way. This pump is illustrated at *A* in the accompanying drawing, and it discharges through the pipe shown and the angle valve *B* into the pressure tank *C*, but formerly there was no tee in this pipe, as it was not needed. The relief valve *D* opened at about 5 pounds above the normal pressure carried, and discharged into the surge tank *E*.

Several changes were made in this plant, one of which consisted of discarding the steam pump and installing a power pump driven by an electric motor. This is shown at *F* and in order to provide a suitable discharge pipe to the pressure tank, a cross was inserted at *G*, but the relief valve *H* was not installed at this time, and this was the dangerous omission.

When the new pump was ready for service, the steam pump was shut down and the angle valve *B* closed. This left the relief valve *D* in its usual place, but there was no connection between it and the pump *F*. Nothing happened as long as the new pump, together with its controlling mechanism, worked perfectly, for when a pressure of 145 pounds was secured the current was shut off by suitable devices, and the pump stopped. When the pressure fell to 125 pounds it started up again and maintained a working pressure between these two extremes.

Controller Failed to Operate

One day the controller failed to operate, as something prevented the automatic switch from making a proper contact; consequently, the pump continued to deliver water after the maximum working pressure was secured, and it continued to rise beyond a safe limit, causing joints in the pressure tank to leak, as they were badly strained. This afforded slight relief, and fortunately the trouble was discovered before the tank burst, the current was shut off and the pump stopped.

The manager took warning from this narrow escape, had the relief valve *D* taken off and put on at *H*, where it is doing duty as a relief from over-pressure of the pump *F*, and since this change was made it has performed its part well, although it is quite small when compared with the discharge pipes, as the illustration shows.

The opening left at *D* was covered by a cap; therefore, the steam pump *A* is ready for use whenever an emergency requires, in which case the angle valve *B* would be opened and the relief valve *H* would answer the purpose for which it was installed, as far as its capacity ad-

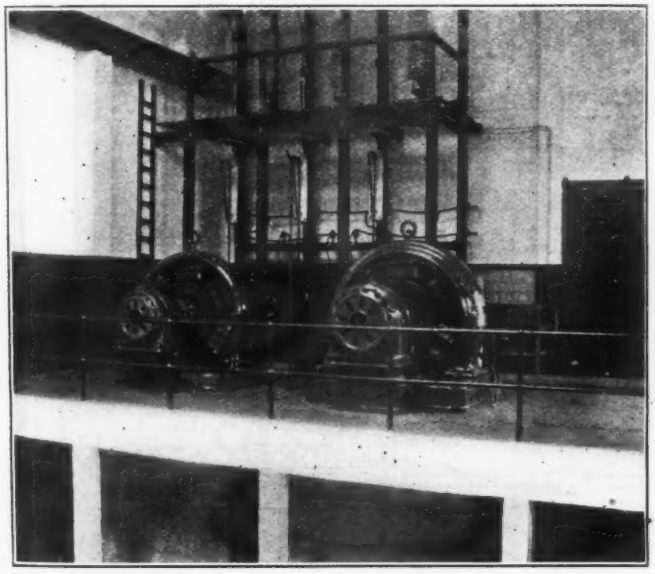


FIG. 3. ROTARY CONVERTERS

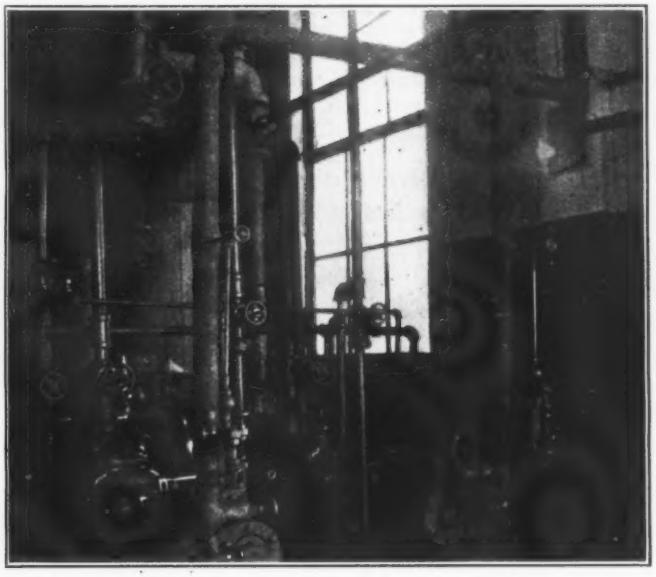


FIG. 4. FEED PUMPS AND HEATER

mits, but it should be larger in order to become a safety valve, which is the real object sought in installing it.

Dangerous Features

When the steam pump *A* was first used it was impossible to raise the pressure to a dangerous point (unless the pump delivered water faster than *D* could discharge it), because the relief valve could not be shut off by a stop valve manipulated by a careless or ignorant engineer, but now this is possible under the following conditions: If *F* is disabled or "laid up" for repairs, *A* may be started before the angle valve *B* is opened, and as there is no way for relief (because a cap is screwed on at *D*), pressure may be quickly raised to a dangerous point, but it cannot affect the tank *C*, as *B* prevents it.

Another dangerous feature of this plant is that if the stop valve *I* is closed to pack or otherwise repair the pump, when the work is completed the engineer may fail to open *I* before he starts *F*; therefore, a very high pressure can be quickly created on the pump cylinders and connections in this way, and it may cause one or more of them to burst, resulting in trouble and expense. This has happened in other cases, one of which was not far from this pump; therefore, precautions ought to be taken in this case and all others like it.

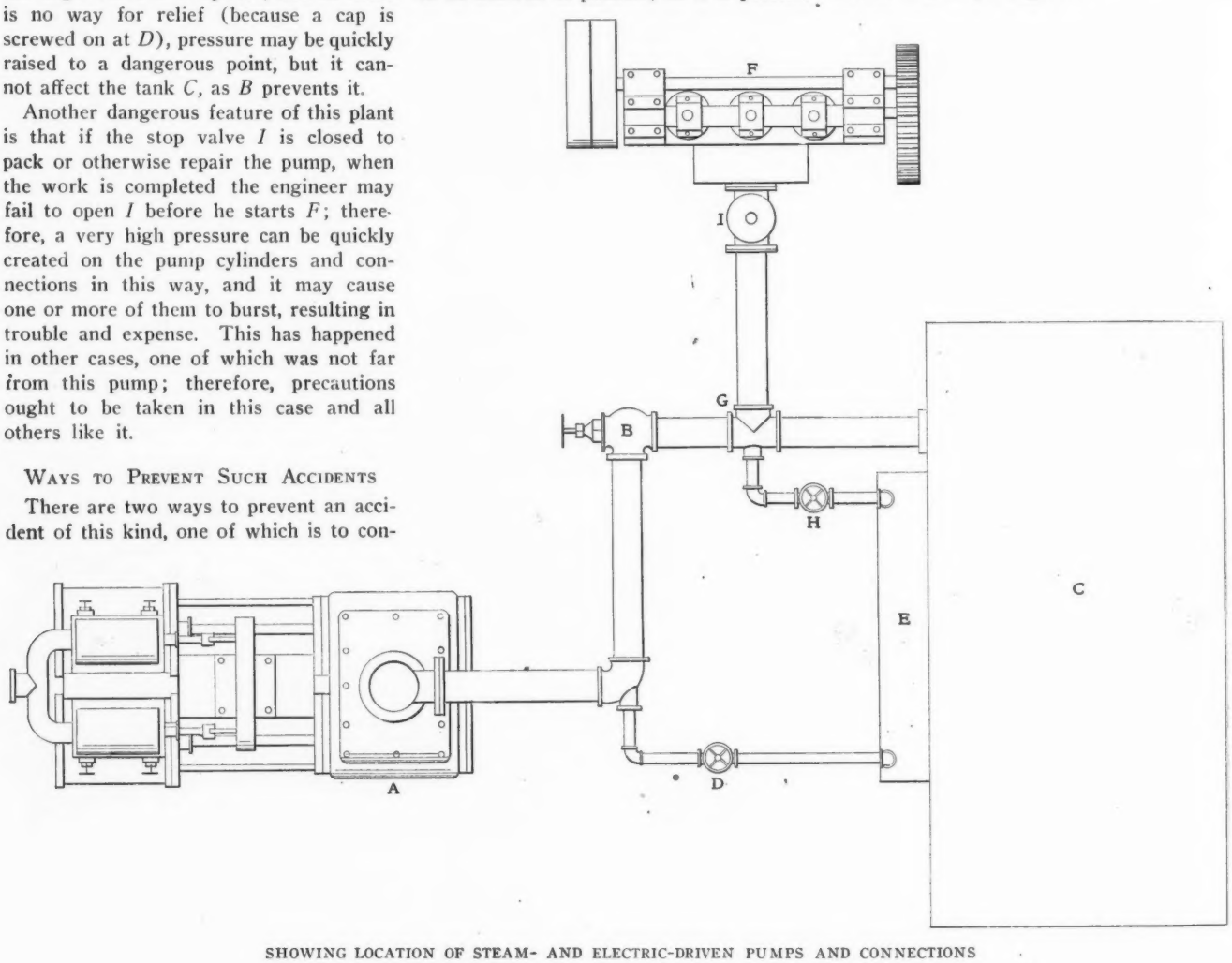
Ways to Prevent Such Accidents

There are two ways to prevent an accident of this kind, one of which is to connect a relief valve between *F* and *I*, thus making it impossible to shut in the water delivered, and the other is to use a check valve at *I*. An objection to the latter is found in the fact that there should always be a stop valve in the discharge pipe of a pump, whether a check valve is used or not.

The relief valve *D* ought not to have been removed until the pump *A* was taken out, because it is possible for it to be started up and cause trouble as above mentioned. To purchase a new relief valve when there is one on hand that will soon be discarded may seem to be a waste of money, but a larger valve would be a great improvement in this case. Furthermore, the manager who frequently runs great risks in order to save small amounts of money (provided all plans work well) sometimes escapes trouble, extra expense and blame for foolish management, but he who is always on the safe side never has to regret that a mistaken and short-sighted policy caused loss of life or limb, or resulted in the destruction of valuable property.

In this case a variation of 20 pounds between the highest and the lowest carried on the pressure tank is mentioned, and this may seem to be more than ought to be allowed in practice, as it is possible to adjust these electrical devices much closer than the above indicates. If electric current is generated on the premises, and exhaust steam is used for other purposes, a variation of 10 pounds, or even less, might be adopted, but where it is bought from a central station, economy in its use becomes an important factor.

More current is used for starting a motor in connection with the machinery of a power pump than is required for keeping it in motion for ordinary elevator service, hence a plan that makes it necessary to start and stop many times per day is more expensive than if fewer changes proved satisfactory. If the limit of variation was placed at 5 pounds, the pump would be started a certain number of times per hour, but by increasing this limit to 20 the pump runs much more steadily, hence takes less current for the same elevator service, taking it as found in practice.



SHOWING LOCATION OF STEAM- AND ELECTRIC-DRIVEN PUMPS AND CONNECTIONS

The Strength of Aqua Ammonia

By F. E. Matthews

A correspondent asks: "If aqua ammonia tests 26 degrees Baumé at 60 degrees Fahrenheit, what will the same ammonia test at 76 degrees?"

The addition of a quantity of anhydrous ammonia to a quantity of water to make aqua ammonia decreases the specific gravity of the liquid. For example (see Table 1), the addition of sufficient anhydrous to pure water to make an aqua solution of 38 per cent. by weight decreases the specific gravity from 1.0, or unity, for the water to 0.88 for the resulting aqua. The addition of heat also decreases the specific gravity of a substance by causing it to expand.

One cubic foot of water at its temperature of maximum density at 39 degrees Fahrenheit weighs 62.425 pounds. Above this temperature its weight decreases.

Some idea of the rate of decrease in weight with increase in temperature may be gained from the fact that at 62 degrees Fahrenheit it weighs 62.35 pounds per cubic foot, and at its boiling point under atmospheric pressure, 212 degrees Fahrenheit, it weighs 59.64 pounds. In other words, the specific gravity of the water has been reduced from 1.0 at 39 degrees Fahrenheit to 59.64 ÷ 62.425 = 0.954 at 212 degrees Fahrenheit.

Since both increasing the strength of the solution and raising the temperature of the solution decrease its specific gravity, it is obvious that a change of temperature, if not corrected for, will lead to erroneous notions regarding the strength of the solution, too high a temperature by producing too light a solution leading one to think that the solution is stronger than it really is, and too low a temperature by producing too heavy a solution leading one to think the solution weaker than it really is.

TABLE 1. STRENGTH OF AMMONIA LIQUOR

Percentage of Ammonia by Weight.	Specific Gravity.	Degrees Baumé Water 10.	Degrees Baumé Water 0.
0	1.000	10	0
1	0.993	11	1
2	0.986	12	2
4	0.979	13	3
6	0.972	14	4
8	0.966	15	5
10	0.960	16	6
12	0.953	17.1	7
14	0.945	18.3	8.2
16	0.938	19.5	9.2
18	0.931	20.7	10.3
20	0.925	21.7	11.2
22	0.919	22.8	12.3
24	0.913	23.9	13.2
26	0.907	24.8	14.3
28	0.902	25.7	15.2
30	0.897	26.6	16.2
32	0.892	27.5	17.3
34	0.888	28.4	18.2
36	0.884	29.3	19.1
38	0.880	30.2	20.0

TABLE 2. CORRECTION FOR TEMPERATURE OF AQUA AMMONIA.*

The figures in top row indicate degrees Fahrenheit; those beneath give the strength of Ammonia at 60.°

Degrees Baumé.	60°	66°	67°	68°	72°	74°	76°	78°	81°	84°	88°	90°	92°	95°	96°	100°	102°	108°	109°
18	18	...	...	17¾	...	...	17½	...	...	17¼	...	...	17	...	...	16¾	...	16½	...
18¼	18¼	...	...	18	...	...	17¾	...	...	17½	...	...	17¼	...	...	17	...	16¾	...
18½	18½	...	...	18¼	...	...	18	...	...	17¾	...	...	17½	...	...	17¼	...	17	...
18¾	18¾	...	...	18½	...	...	18¼	...	...	18	...	...	17¾	...	...	17½	...	17¼	...
19	19	...	...	18¾	...	...	18½	...	...	18¼	...	...	18	...	...	17¾	...	17½	...
19¼	19¼	...	...	19	...	...	18¾	...	...	18½	...	...	18¼	...	...	18	...	17¾	...
19½	19½	...	...	19¼	...	...	19	...	...	18¾	...	...	18½	...	...	18¼	...	18	...
19¾	19¾	...	...	19½	...	...	19¼	...	...	19	...	...	18¾	...	...	18½	...	18¼	...
20	20	...	19¾	...	...	19½	...	...	19¼	...	19	...	...	18¾	...	...	18½	...	18¼
20¼	20¼	...	20	...	...	19¾	...	...	19½	...	19¼	...	...	19	...	...	18¾	...	18½
20½	20½	...	20¼	...	...	20	...	...	19¾	...	19½	...	...	19¼	...	...	19	...	18¾
20¾	20¾	...	20½	...	...	20¼	...	...	20	...	19¾	...	...	19½	...	...	19¼	...	19
21	21	...	20¾	...	...	20½	...	...	20¼	...	20	...	...	19¾	...	...	19½	...	19¼
21¼	21¼	...	21	...	...	20¾	...	...	20½	...	20¼	...	...	20	...	...	19¾	...	19½
21½	21½	...	21¼	...	...	21	...	...	20¾	...	20½	...	...	20¼	...	...	20	...	19¾
21¾	21¾	...	21½	...	...	21¼	...	...	21	...	20¾	...	...	20½	...	...	20¼	...	20
22	22	21¾	...	...	21½	...	...	21¼	...	21	...	20¾	...	...	20½	...	20½	20	...
22¼	22¼	22	...	...	21¾	...	...	21½	...	21¼	...	21	...	...	20¾	...	20½	20¼	...
22½	22½	22¼	...	...	22	...	...	21¾	...	21½	...	21¼	...	...	21	...	20¾	20½	...
22¾	22¾	22½	...	...	22¼	...	...	22	...	21¾	...	21½	...	...	21¼	...	21	20¾	...
23	23	22¾	...	...	22½	...	...	22¼	...	22	...	21¾	...	...	21½	...	21¼	21	...
23¼	23¼	23	...	...	22¾	...	...	22½	...	22¼	...	22	...	...	21¾	...	21½	21¼	...
23½	23½	23¼	...	...	23	...	...	22¾	...	22½	...	22¼	...	...	22	...	21¾	21½	...

	60°	64°	65°	68°	70°	72°	75°	76°	80°	84°	85°	88°	90°	92°	95°	96°	100°	104°	105°
23¾	23¾	...	23½	...	23¼	...	23	...	22¾	...	22½	...	22¼	...	22	...	21¾	...	21½
24	24	...	23¾	...	23½	...	23¼	...	23	...	22¾	...	22½	...	22¼	...	22	...	21¾
24¼	24¼	...	24	...	23¾	...	23½	...	23¼	...	23	...	22¾	...	22½	...	22¼	...	22
24½	24½	...	24¼	...	24	...	23¾	...	23½	...	23¼	...	23	...	22¾	...	22½	...	22¼
24¾	24¾	...	24½	...	24¼	...	24	...	23¾	...	23½	...	23¼	...	23	...	22¾	...	22½
25	25	...	24¾	...	24½	...	24¼	...	24	...	23¾	...	23½	...	23¼	...	23	...	22¾
25¼	25¼	...	25	...	24¾	...	24½	...	24¼	...	24	...	23¾	...	23½	...	23¼	...	23
25½	25½	25¼	...	25	...	24¾	...	24½	24¼	24	23¾	...	23½	...	23¼	23	22¾	...	...
25¾	25¾	25½	...	25¼	...	25	...	24¾	24½	24¼	...	24	...	23¾	...	23½	23¼	23	...
26	26	25¾	...	25½	...	25¼	...	25	24¾	24½	24¼	...	24¼	...	24	...	23¾	23½	23¼
26¼	26¼	26	...	25¾	...	25½	...	25¼	25	24¾	24½	...	24½	...	24¼	...	24	23¾	23½
26½	26½	26¼	...	26	...	25¾	...	25½	25¼	25	24¾	...	24¾	...	24½	...	24¼	24	23¾
26¾	26¾	26½	...	26¼	...	26	...	25¾	25½	25¼	25	...	24¾	...	24½	...	24½	24¼	24
27	27	26¾	...	26½	...	26¼	...	26	25¾	25½	25¼	...	25¼	...	25	...	24¾	24½	24¼
27¼	27¼	27	...	26¾	...	26½	...	26¼	26	25¾	25½	...	25¼	...	25¼	...	25	24¾	24½
27½	27½	27¼	...	27	...	26¾	...	26½	26¼	26	25¾	...	25¾	...	25½	...	25¼	25	24¾
27¾	27¾	27½	...	27¼	...	27	...	26¾	26½	26¼	26	...	26	...	25¾	...	25½	25¼	25
28	28	27¾	...	27½	...	27¼	...	27	26¾	26½	26¼	...	26¼	...	26	...	25¾	25½	25¼

The specific gravity of aqua ammonia changes with the temperature at which it is measured with the hydrometer. The readings are too high if the temperature of the ammonia is over 60° F., and too low if under. To ascertain the exact strength of ammonia at 60° F., make the corrections for temperature in accordance with the table, thus: 26¼° ammonia, measured at a temperature of 80° F., is equal to 25¼° ammonia at a temperature of 60° F.

*This table was published in 1899 in *Machinery of Refrigeration*, by Norman Selfe, and is credited "by permission of Henry Vogt Machine Co."

In order to determine the true strength of a solution one must, therefore, either heat or cool the solution to some predetermined standard temperature, as, for example, to 60 degrees Fahrenheit, which has been adopted as the standard temperature for taking Beaumé hydrometer readings, or apply an appropriate factor of correction which is a function of the expression for the expansion of the solution in question. As water does not expand equally for each degree increase in temperature, and as, in fact, it even expands with a decreasing temperature below 39 degrees Fahrenheit, the factor of correction can be determined more accurately experimentally.

For convenience, the accompanying Table 2 has been arranged for indicating at a glance the *actual* 60-degree Fahrenheit Beaumé density corresponding to the *apparent* Beaumé density as indicated by a Beaumé hydrometer at temperatures above 60 degrees Fahrenheit.

Take, for example, the following: If aqua ammonia tests 26 degrees at 60 degrees Fahrenheit, what will it test at 76 degrees Fahrenheit?"

From the table it is readily seen that 26-degree aqua at 60 degrees Fahrenheit, when heated to 76 degrees Fahrenheit, will test 25 degrees. This is determined by locating the strength of ammonia required at 60 degrees Fahrenheit (in the body of the table) under the increased temperature (at the top of the table), and then referring to the left-hand column opposite the required 60-degree Fahrenheit standard temperature. In this case 25 degrees will be found opposite 26 degrees under 76 degrees Fahrenheit, indicating that the extra heat required to raise the temperature of the solution from 60 degrees Fahrenheit to 76 degrees Fahrenheit caused it to make the Beaumé hydrometer read 25 degrees, when the strength of solution would have caused it to read 26 degrees had the temperature been 60 degrees Fahrenheit.

Ohio Society of Mechanical, Electrical and Steam Engineers

The next meeting of this society will be held at Toledo, Ohio, November 20 and 21. A large attendance is anticipated in consequence of unusually interesting features to be brought out, full particulars of which will be announced shortly. In connection with this meeting, also, the society will publish its *Proceedings* itself, which will enable it to get all the papers presented into print, which has not been the case heretofore.

Incidentally, it is announced that William A. Rowe has resigned as secretary, having accepted a situation with the American Blower Company, and David Gaehr has been appointed to fill the unexpired term of Mr. Rowe. Further particulars may be obtained of President Frederick W. Ballard, 601 Canal road, Cleveland, Ohio.

The Swedish State Railways, by way of experiment, will take over the working for a year of the large Majeujänka peat deposits in North Sweden. Should the result be as satisfactory as is anticipated, the State Railways are understood to intend going in for peat production on a large scale in the north of Sweden. It is not for locomotive fuel the peat is intended, but for heating of waiting rooms, offices, engine houses, etc.

The Plunger Hydraulic Elevator

Rack and Pinion Valves for Otis Freight Elevators; the Type of Valve Used for High Speed; Notes on the Care of the Plunger and Ropes

BY WILLIAM BAXTER, JR.

Rack-and-pinion Valve

The rack-and-pinion valve, which is used for elevators that run at a velocity too great for the lever valve, is shown in Fig. 265. The valve itself is the same as the lever valve, but the connecting rod *F'* is replaced by the rack *R*, and this meshes with a pinion *P* that is mounted on the shaft that carries the hand sheave *S*. The rack *R* is made of a round rod with the teeth cut on one side. A casing *D* is provided to cover the rack and pinion, and this is clamped against the upper end of the valve cylinder by means of the cap *D'*. Opposite the pinion *P* the cover *D* has a finished surface against which the rack bears so as to be held in mesh with the pinion. This sliding surface and the pinion shaft are provided with grease cups *E* and *F* to keep them properly lubricated. The rack is so formed at the ends that it cannot be run out of gear, even if there are no stops outside of the valve to limit the movement of the hand rope. When the pinion reaches the last tooth it strikes the curved end of the rack and can go no farther.

Type of Valve Used for High Speed

The type of valve used when the car speed is so great that the plain rack-and-pinion valve will not give sufficient hand-rope movement, is shown in Fig. 266, which presents vertical elevations taken at right angles to each other. The hand-rope sheave *S* is mounted on a shaft *A* that carries a pinion *B*, which meshes with a gear wheel *C* mounted on a second shaft *D*. This shaft carries a second pinion *E* that meshes with the rack *F* on the end of the valve rod, as is shown in Fig. 267. The relative positions of these parts is more fully shown in the plan view of the valve, at the top of the drawing. The pinion *B* and gear *C* are covered with a casing, and so are the rack *F* and pinion *E*, as is clearly shown in Fig. 268. In Fig. 267 it will be noticed that the rack *F* is provided with stops on the back at each end so that it cannot be run out of gear with the pinion.

All the valves shown in the preceding illustrations are balanced insofar as the pressure of the supply water is concerned, as this pushes up against the piston *A* and down against the piston *B*, and as both pistons are of the same diameter, the pushes are balanced, but if the discharge tank is higher up than the valve, as is generally the case, the valve will not be in balance because there will be a pressure acting under the piston *C* that will be greater than the atmospheric pressure acting on the top of the piston *C* that will be greater than the atmospheric pressure acting on the top of the piston *A*. For cases of this kind it is necessary to provide another valve piston under *C* so that the back pressure from the discharge tank may act upon it and thus balance the pressure acting under the piston *C*. The type of valve used for such installations is shown in Fig. 268. The only difference between this and the other valves is that a section is added to the lower end of the valve cylinder and the valve rod is lengthened out so as to carry an additional valve piston *D*. With this construction the two pistons *C* and *D* balance the back pressure from the discharge tank, and the pistons *A* and *B* balance the pressure from the supply pipe.

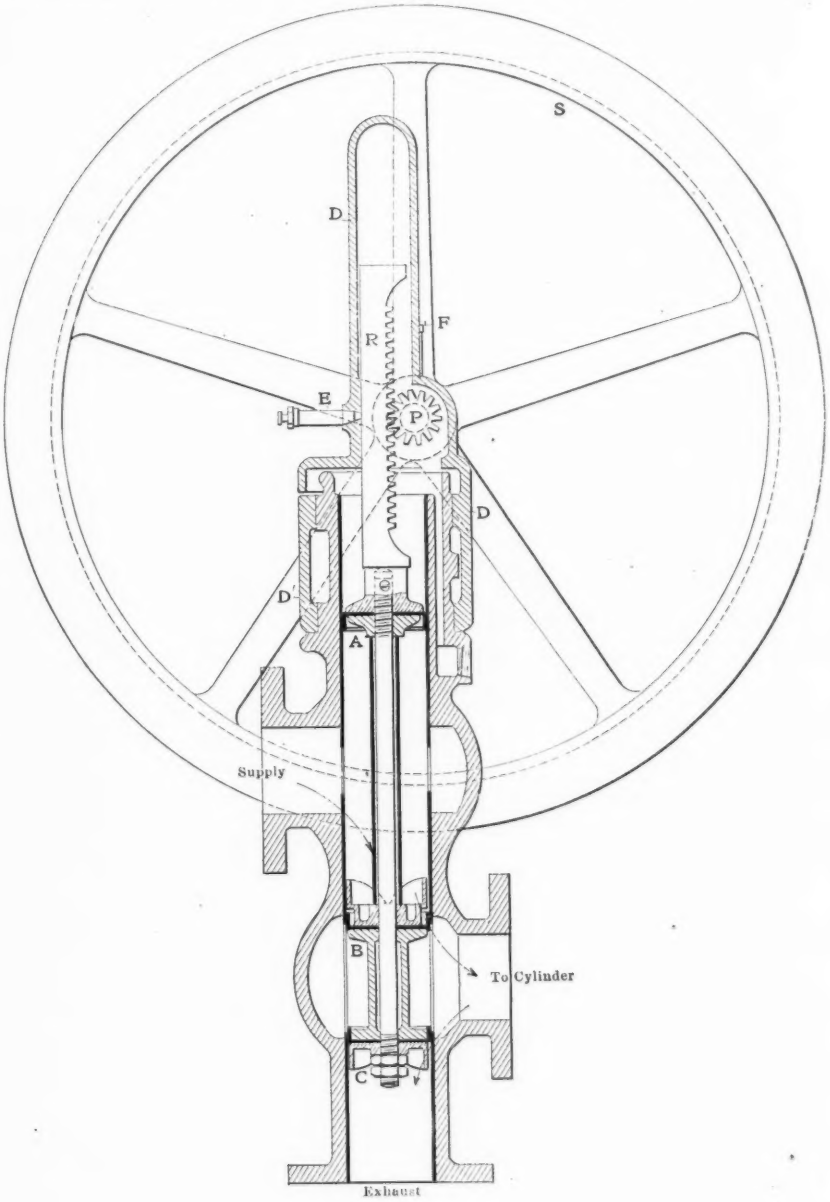


FIG. 265

Plunger elevators have fewer moving parts than cable hydraulic machines,

hence they should be easier to keep in proper running order. The counterbalance ropes run over a sheave located at the top of the elevator well in the same position as the main overhead sheave of cable-hoisted elevators. This sheave is

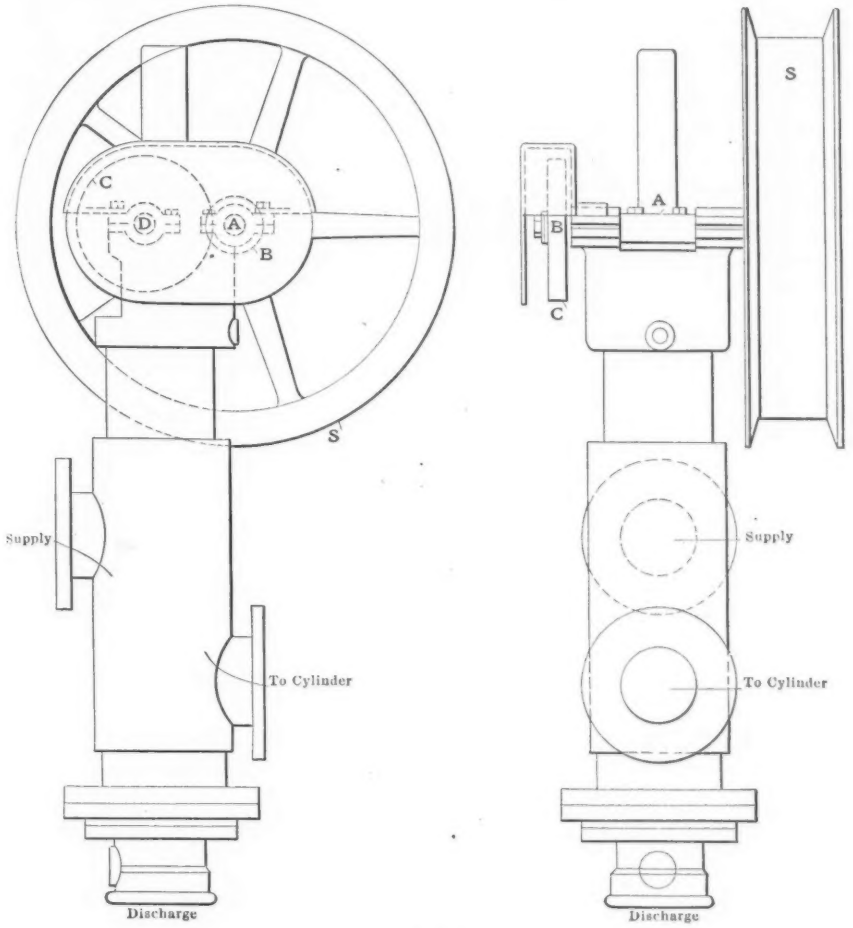


FIG. 266

of the same type as those used with cable elevators and is mounted in the same way, so that it requires the same attention. The ropes that run over it do not require as close inspection as the lifting ropes of cable machines because they are several times as large as is necessary to support the weight of the counterbalance, owing to the fact that they not only hold this weight, but also act as a compensating balance to offset the varying weight of the column of water displaced by the plunger. The diameter of the plunger is almost invariably 6½ inches, so that the water displaced for each foot of length is 0.2304 cubic foot, and the weight of this quantity of water is about 14.33 pounds. The weight of the ropes required to compensate for the varying weight of the water displaced by the plunger is just one-half this amount, as can be easily seen from the fact that each foot of rope hanging above the car adds its weight to the latter, while each foot of rope hanging above the counterbalance deducts its weight from that of the car; hence, to exactly balance the water displaced by the plunger the ropes must weigh one-half as much per running foot.

Although the ropes are far stronger than necessary, it is important to keep them all drawn up to the same tension, and this can be done with a sufficient degree of accuracy by pushing them sidewise at a point several feet from the end and noting whether they all offer about the same resistance to being moved. The end-fastening bolts must be held so that they may not work loose and slack the ropes. As a rule these bolts are provided with means for holding the nuts from turning, but even these locking devices can get out of order occasionally, and they should be inspected frequently.

The ropes that operate the valves should be kept in perfect condition, and the sheaves over which they run should have the bearings well lubricated; care should be taken that there is nothing nearby that can fall into them and cause the ropes to run off, or to be jammed. This applies especially to the automatic-stop valve ropes, for if these should become disabled the car would in all probability run far enough above the upper floor to do damage, or strike the lower bumpers violently the first time the operator permitted the car to run to the end of the trip without closing the main valve.

Plunger Will Give Little Trouble.

The plunger, if kept in proper condition, will give very little trouble, but if an elevator is out of service for some time and the plunger becomes rusty from want of proper protection, when it is started up the rough surface will act upon the packing like sandpaper, and soon cause it to leak. Whenever an elevator is put out of commission for any length of time, which is unusual, the plunger should be run slowly on the last downward trip that it makes, and the surface should be wiped dry and then covered with a hard lubricating grease, so that in passing down through the stuffing box into the cylinder, all the grease will not be rubbed off, but a thin layer will be

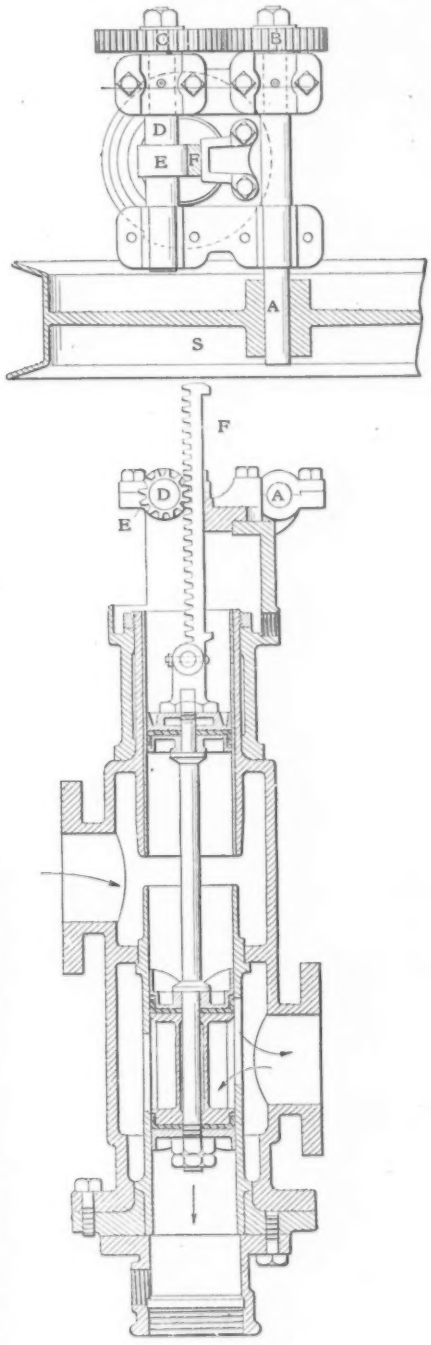


FIG. 267

left that will serve to protect the metal. If the elevator plunger is lubricated by a lubricating compound put in the water, it will not be necessary to grease the plunger, as it will receive a protective coating from the greasy water.

When an elevator that has been idle for some time is started up, the plunger should be carefully examined, and if it shows any rough spots they should be

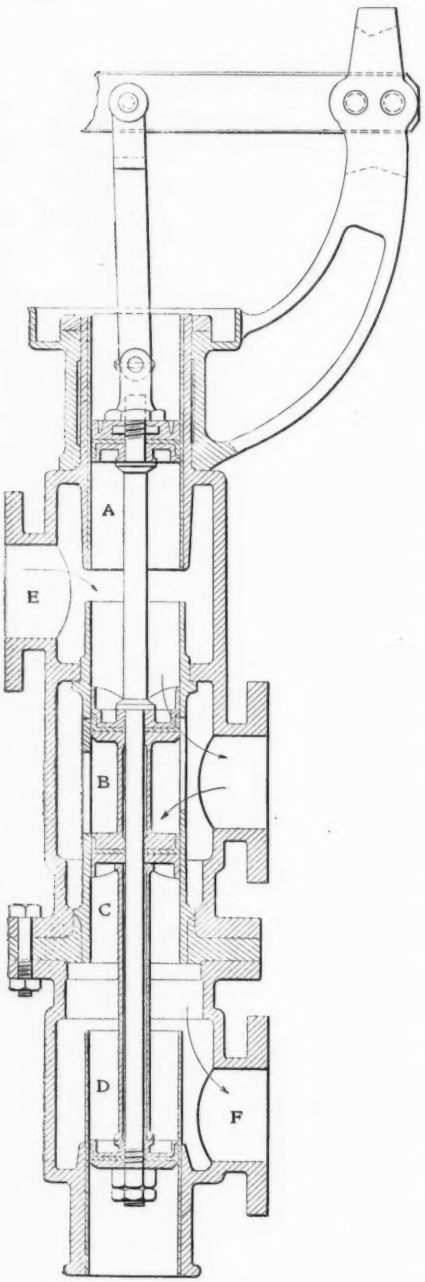


FIG. 268

smoothed off, but emery should not be used for this purpose. As a rule use the softest polishing material that will do the work, such as whiting, pumice stone, and in extreme cases sandpaper. Draw-filing with a very fine file is the best means for smoothing the rough spots if they are very rough, but be sure the file is a dead smooth cut or next to it. After draw-filing a fine polish can be obtained by using the finest grade of sandpaper and finishing with rouge cloth. In fact, for ordinary roughness, the rouge cloth alone will answer every purpose.

The Quality of Steam

By Harold V. Coes

In the September 1 issue was published an article on the "Quality of Steam," by W. D. Spooner, which attracted my attention. I desire to correct some impressions left by Mr. Spooner's article and point out some things he omitted, as well as to give the mathematical demonstration and use of the throttling calorimeter of the reservoir type.

This calorimeter, shown in Fig. 1, consists essentially of a reservoir which can be made out of a piece of 4-inch extra-heavy pipe about 10 inches long, capped by two blank flanges, the upper flange being tapped for a ¾-inch pipe connected to a nozzle for the steam supply; a brass thermometer well and a siphon for a test gage. The thermometer well should extend into the calorimeter about two-thirds of the reservoir's hight. The steam-supply pipe is provided with a throttle valve near the calorimeter. The lower cap is tapped for a 1-inch pipe in which is placed a back-pressure valve.

The boiler pressure should be determined by a test gage on the main steam line near the calorimeter, and not as Mr. Spooner has shown it in his sketch. In his case the gage is liable to be in error due to the velocity of the steam flowing in the pipe, which will consequently make the gage reading too low.

The completed calorimeter is wrapped in hair felt, of the customary thickness for a 4-inch pipe, and then lagged with wood to reduce the radiation of heat to a minimum.

When steam is to be sampled the throttle valve is opened wide and steam allowed to flow through the calorimeter for about ten minutes before readings are taken, in order to warm up the apparatus. The back-pressure valve is then adjusted until a pressure of about 15 pounds per inch is registered on the calorimeter gage. The thermometer well is then filled with a heavy cylinder oil and the thermometer allowed to stand until the readings have become constant. Readings are then taken every three to five minutes, for about fifteen minutes, of the boiler pressure, and the pressure and temperature in the calorimeter. The results are then averaged and used as follows:

Let

p = Boiler pressure,

p_1 = Pressure in the calorimeter,

v = Heat of vaporization corresponding to the pressure p,

q = Heat of the water, corresponding to the pressure p.

t_1 = Temperature of the steam corresponding to the pressure p_1 in the calorimeter,

t_s = Temperature in the calorimeter,

x = Per cent. of steam in a mixture of 100 parts steam and water,

λ_1 = Total heat of a pound of steam at the pressure p.

Then since no heat is radiated, we must have the amount of heat in a pound of steam at boiler pressure equal the heat in the calorimeter, or

$$x\,v + q = \lambda_1 + C_p\,(t_s - t_1).$$

Therefore,

$$x = \left[\frac{\lambda_1 + C_p\,(t_s - t_1) - q}{v}\right] 100.$$

Since there seems to be no agreement of the authorities on the value of C_p,

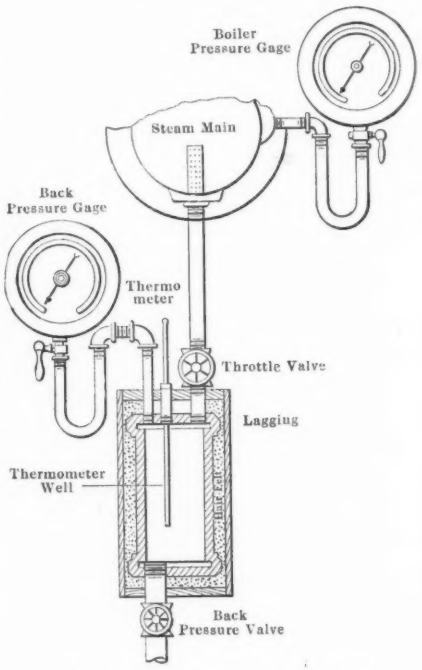


FIG. 1. DETAILS OF CALORIMETER

specific heat of superheated steam at constant pressure, the customary value of 0.48 will be used. The other factors in the equation are all obtained by observation and from the steam tables.

Take for example:

Pressure in main steam line, $p = 69.8$ pounds per square inch.

Pressure in calorimeter, $p_1 = 12$ pounds per square inch.

Pressure of atmosphere, $p_a = 14.8$ pounds per square inch.*

Temperature in calorimeter, $t_s = 268.2$ degrees Fahrenheit.

Absolute pressure in steam pipe equals

$$P = p + p_a,$$

or

$$69.8 + 14.8 = 84.6$$

pounds per square inch.

*This may be obtained from the weather bureau.

Absolute pressure in calorimeter equals.

$$P_1 = p_1 + p_a,$$

or

$$12 + 14.8 = 26.8$$

pounds per square inch.

t_1 at 26.8 pounds = 243.9 degrees Fahrenheit.

λ_1 at 26.8 pounds = 1156.4 B.t.u.

r at 84.6 pounds = 892.7 B.t.u.

q at 84.6 pounds = 285.5 B.t.u.

The priming then, is

$$100 - \left[\frac{1156.4 + 0.48\,(268.2 - 243.9) - 285.5}{892.7}\right] 100$$

$$= 1.2 \text{ per cent.}$$

This type of calorimeter can be used only, as Mr. Spooner states, when the priming is not excessive, otherwise the throttling will fail to superheat the steam. To find this limit for any pressure, t_s may be made equal to t_1 in the general equation. That is, we assume that the steam is just dry and saturated at the limit of the calorimeter.

Mr. Spooner neglects to state that with a throttling calorimeter of the disk type, unless the disk is properly designed and located in the flanges, the results of the test will be impaired by the impact of the steam on the disk.

As I understand Mr. Spooner's demonstration of the expansion of steam in the throttling calorimeter, and his computation of the superheat temperature, he must have assumed that the temperatures of saturated steam are proportional to the total heat, which, of course, is wrong. His final temperature in the calorimeter is higher than his initial temperature in the boiler, which would seem to border on perpetual motion.

If in the equation for the throttling calorimeter we assume the steam is dry and saturated at the entrance to the nozzle or orifice, and use the same data that Mr. Spooner gives in his example, we get:

$$\lambda_b = \lambda_1 + C_p\,(t_s - t_1),$$

where λ_b replaces $x\,r + q$.

$$t_s - t_1 = \frac{\lambda_b - \lambda_1}{C_p},$$

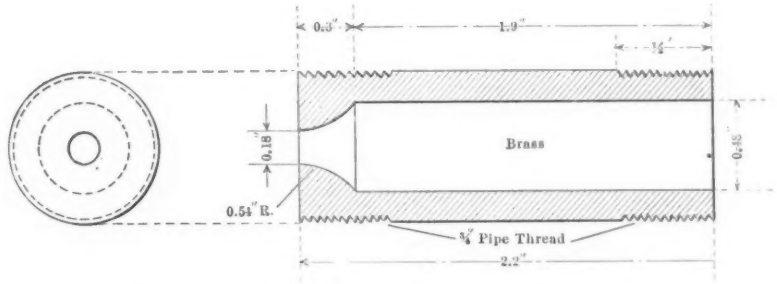


FIG. 2. STANDARD ORIFICE FOR THROTTLING CALORIMETER

The following table has been computed by Professor Peabody, giving these limits:

Pressure.		Priming.	Per Cent.
Absolute.	Gage.		
300	285.3	0.077	77
250	235.3	0.070	70
200	185.3	0.061	61
175	160.3	0.058	58
150	135.3	0.052	52
125	110.3	0.046	46
100	85.3	0.040	40
75	60.3	0.032	32
50	35.3	0.023	23

In case the calorimeter is operating at or near the limit, it is absolutely essential that the thermometer be accurate, otherwise the calorimeter might show superheating when the steam was dry or moist.

Experiment shows that no correction for radiation need be made when 200 pounds of steam per hour pass through the calorimeter. This amount of steam will pass through an orifice ¼ inch in diameter under a pressure of 70 pounds per square inch, gage. Hence with the nozzle and orifice shown in Fig. 2, no correction need be made. I have obtained excellent results with the orifice and nozzle shown herewith.

$$t_s = \frac{\lambda_b - \lambda_1}{C_p} + t_1,$$

or

$$\frac{1181.8 - 1146.6}{0.48} + 212 = 73.33 + 212 =$$

285.33 *degrees Fahrenheit*

for the superheat temperature, instead of 452 degrees Fahrenheit.

Again; Mr. Spooner states that a thermometer will give a reading too low for the boiler pressure. If Mr. Spooner is familiar with precision, physicist's thermometers, he would know that such a thermometer, connected for steam exposure and properly calibrated is as accurate an instrument in the hands of an expert as can possibly be obtained.

The New York Board of Education has caused to be opened an evening trade school, known as the "Stuyvesant," located on Fifteenth street, near First avenue, New York City. There are several classes in skilled trades, and it was announced that there would be a class in steam engineering. A correspondent informs us, however, that there were not applicants enough to warrant inaugurating such a course, but if 30 applications are forthcoming the class will be opened.

Effect of Altitude on Boiling Point

Altitude affects the temperature at which water boils by affecting the pressure. Boiling is the flying apart of the molecules of the water at the critical point when their centrifugal force overcomes the forces tending to hold them together. One of these forces is the pressure upon the surface of the liquid, and as this is diminished the disruption or boiling can take place when the water has a lower temperature, i.e., when its molecules have less velocity.

During the recent convention of the National Association of Stationary Engineers at Denver, and the subsequent visit of many engineers to the high altitudes of Colorado, much discussion arose as to the effect of altitude upon the barometer and the boiling point. This would appear to be a subject of interest not only to engineers, but to the average tourist as well, and yet there seemed to be nobody who could tell anything about it.

Other things than the depth of atmosphere determine the atmospheric pressure or barometric reading. The principal of these is the temperature. Obviously the colder and denser the air, the greater the pressure for a given depth. Moisture and dryness, winds, atmospheric tides and latitude also affect the pressure. It is impossible, then, to state any definite relation between altitude and atmospheric pressure. Perhaps as satisfactory an index of this relation as is available is the table compiled by Trautwine, from Lieutenant-Colonel R. S. Williamson's standard work upon the barometer. This gives the value by tenths of degrees from 184 to 213 degrees Fahrenheit for a mean temperature between the stations of 32 degrees, with a table of corrections for other mean temperatures. The values for even degrees and at 32 are as follows:

Boiling Point, Degrees F.	Barometer, Inches.	Altitude, Feet Above Sea Level.
185	17.16	14,649
190	19.13	11,799
195	21.26	9,031
200	23.59	6,304
205	26.11	3,642
210	28.85	1,025
212	30.00	At sea level

These figures, being interpreted, mean that while at sea level the barometer stands about 30 inches, and water open to the atmosphere boils at 212 degrees, at the top of Pike's and McClennan's peaks, where the altitude is more than 14,000 feet above sea level, the barometer stands somewhere betwen 17 and 18 inches, and the boiling point of water is somewhere between 185 and 190 degrees. The fact that it is impossible to raise the temperature of water above this point, except under pressure, accounts for the difficulties experienced in cooking, and is the basis for the assertion that cooking by boiling is impossible at such altitudes.

Difficult Tunneling for Water Supply

Providing under Exceptional Difficulties a Large Power Station with Condensing Water from a River of Varying Level and Filled with Debris

BY H. R. MASON

It has been the writer's fortune to be intimately connected with an interesting and rather difficult tunneling operation to provide the condensing water supply for a power station of about 15,000 kilowatts ultimate capacity in a large Western city, and if this article points out a few of the most difficult problems encountered in the installation of condensing plants in the central and lower Mississippi river valley, it will fulfil its mission.

The power station stands about 300 feet from the bank of one of the largest rivers in the West, which has the erratic habit of all Western rivers of varying in level 25 or 30 feet in the course of a normal year, and considerably more when a season of drought and one of flood follow each other. As recorded by Government observers, the variations during the last 50 years at the point where the station was located has been from a minimum of 6 to a maximum of 42 feet, as measured from an arbitrary low-water mark. These changes occur very suddenly and at almost any season of the year, and during the rises the usual amount of foreign matter from sewage and refuse from various manufacturing plants is supplemented by about all the classes of matter which water can carry, ranging from pebbles rolling along the bottom to corn husks, straw, brushwood and trees, which ride at various hights from the bottom as they become waterlogged, the whole mixed with an incredible amount of silt. Hence the problem of designing an intake for condensing water which would furnish a supply at extreme low water and still not become unmanageable at high water, was the first to demand consideration. The bank was found entirely unsuitable, as it was constantly being undermined and washed away by the current, and there was further danger from boats which were often tied up at the bank. It was readily seen that a tunnel was by far the best means for securing the water supply, and the question became: What would be the best way to construct the tunnel?

A Tunnel Through Solid Limestone

The general floor level of the station is about 10 feet above the highest recorded stage of the river, having been established with a view to keeping the main units safe from floods. There is a solid limestone deposit underlying the territory for miles on both sides of the river, being about 30 feet below the surface at the site of the station, the foundations of which rested upon it. This limestone was found to shelve off sharply between the power station and the river, and the bank and bottom of the river itself sloped at a very steep angle. As a depth of 50 feet was sufficient to insure water at all times, the first scheme proposed was to sink a

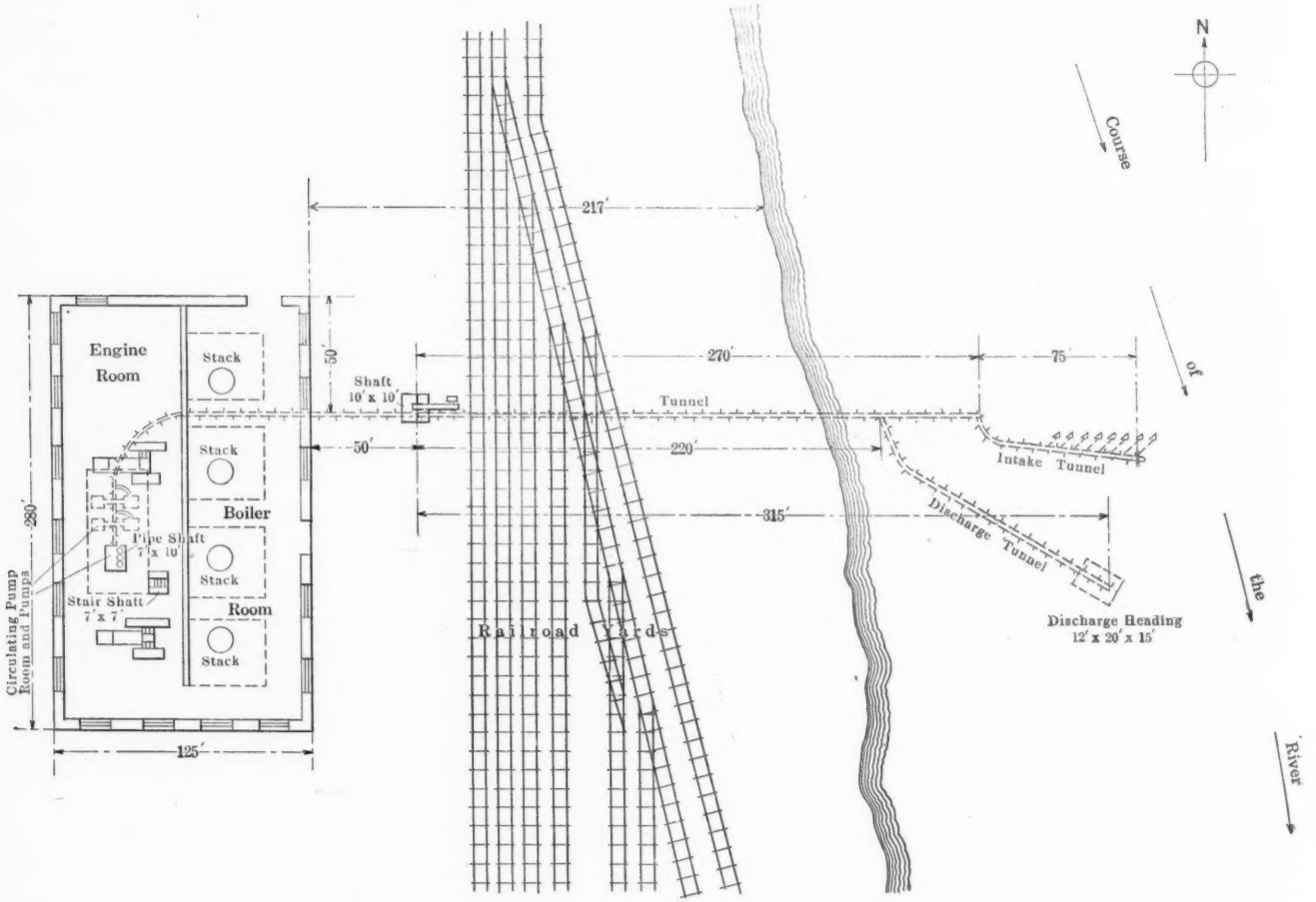


FIG. 1. PLAN OF STATION AND LOCATION OF TUNNEL TO RIVER

shaft down to the rock and run the tunnel along the surface of the rock to the point where it shelved off, and then go down at an incline to a point which would be well below the minimum low-water mark. It was found upon investigation that the course would be through 200 feet or more of exceedingly soft quicksand, grilled profusely with pilings from ancient warehouses, timbers from sunken and forgotten boats, and waterlogged snags deposited by the river in bygone days, so the greater part would have to be done under compressed air, which it was desired to avoid if possible. Soundings were taken to determine as closely as possible the contour of the rock, and this plan was abandoned in favor of sinking the shaft to a depth which would permit a tunnel to be cut through the solid limestone to a point a considerable distance out under the river, and then putting connections up through the roof of the tunnel. Great difficulty was experienced in getting accurate soundings near and in the river to indicate the depth of the rock, as the top ledges were cut in all manner of shapes by water, fissures 10 to 30 feet in depth having been found. It was not wished to go any deeper than positively necessary, and after as thorough exploration as practicable, it was decided from the data gathered that a depth of 90 feet from the surface of the ground should leave ample margin in the rock for a safe roof.

The Plan Finally Adopted

To provide sufficient water for the ultimate capacity of the plant, which was growing rapidly, a 48-inch circular duct would be required. It was decided that 48-inch circular reinforced-concrete ducts should be used for both intake and discharge, and the two pipes laid in a tunnel about 9x9 feet. The rate of flow was to be greatly increased at the intake and outlet connections to the river, the intake to consist of eight 12-inch branches for ease of applying strainers, and the discharge to be three 18-inch pipes. The maximum pressure to which the ducts would be subjected was estimated to be about 50 pounds at the lowest part of the tunnel. A test section of the proposed conduit about 8 feet long was built in a convenient place, and pressure gradually applied with a steam pump. The concrete was about 6 inches thick, and systematically reinforced with steel bars, and it was found impossible to burst it asunder with any pressure available, but at 110 pounds it began to leak badly, and at 150 pounds it leaked water from numerous cracks to the capacity of the pump, which was about 50 gallons per minute. Upon reducing the pressure to 50 pounds again, the leakage nearly all stopped. Considering the fact that this concrete had not had time to set fully, the results had a very satisfactory appearance, and it has now been found that after two years' service, there is scarcely a drop of leakage in nearly 600 feet of this conduit.

Pumps 45 Feet below Engine-room Floor

A 10x10-foot shaft was accordingly located about 50 feet from the north end of the power station, between the buildings and the river, and a suitable derrick and hoist installed. The shaft was sunk to the predetermined depth through about 20 feet of loose earth and 70 feet of rock, and tunneling was commenced in both directions, the general trend being east and west. The west extension was carried on a slight upward grade to a point about under the center of the engine room, and a turn made there so as to extend it under nearly the whole length of the building to permit of easy connection to the circulating pumps. The complete equipment of the station had not then been installed, and the existing machinery was near the south end. When the proper location had been reached, a 7x10-foot shaft was cut, working from top and bottom, connecting to the engine-room basement.

Centrifugal circulating pumps had been selected on account of the gritty nature of the water, and as they are much more reliable when so placed that the water can flow to them, it was decided to set them at an elevation somewhat below the low-water stage of the river, which would be about 45 feet below the engine-room floor level. A room was cut out of the solid rock at that level large enough to accommodate the pumps, and the discharge pipes of the pumps extended up the shaft to the condensers in the basement, 28 feet above, and the exhaust pipes extended down the remaining distance to the condensers. In this section perfectly solid rock was encountered the whole distance, with scarcely a flaw or a drop of water, and, the surveying work having been accurately done, the section was completed in exact accordance with the original plans.

Serious Difficulties Arise

In the east section, however, many difficulties, some of them rather serious, were met and had to be overcome. After going about 130 feet to the east from the shaft, considerable seepage was encountered and the following system of pilot holes was started and maintained to the end: About 5 feet was blasted out at each cut, and three of the holes at certain locations were extended to a distance of about 18 feet ahead of the working face. The

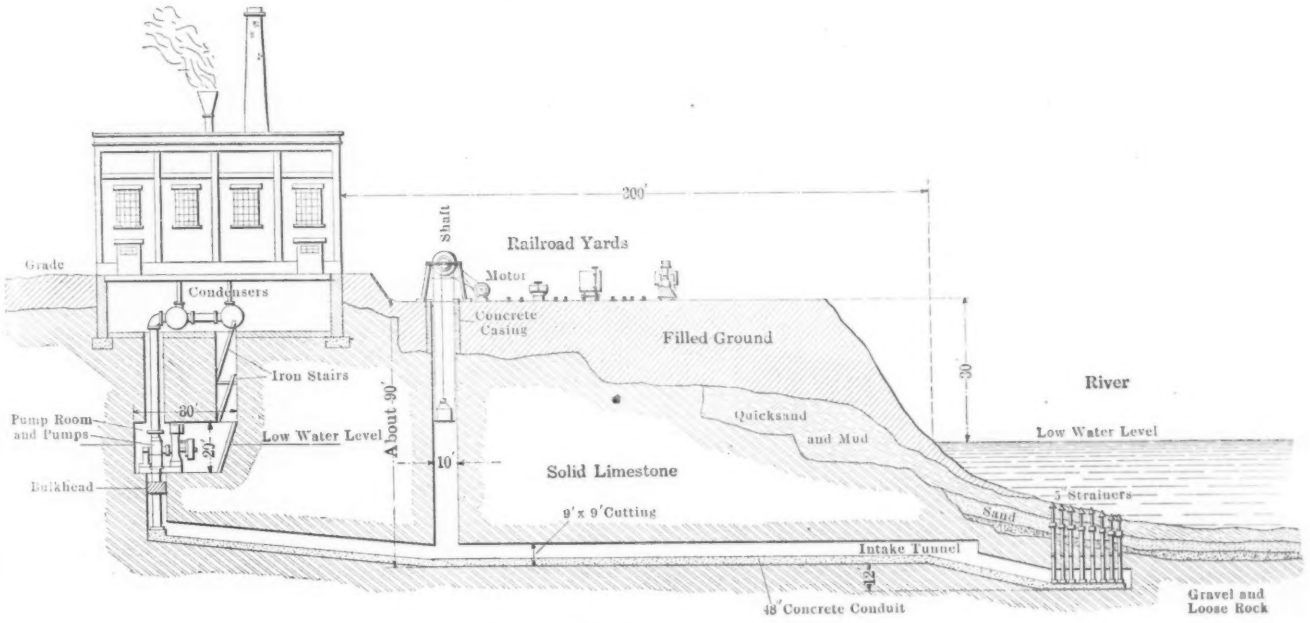


FIG. 2. PROFILE OF INTAKE TUNNEL

river was rather high about this time, and including a slight down grade the tunnel was at a depth of nearly 90 feet below the surface of the water, corresponding to a pressure due to the water of about 40 pounds per square inch, and if any of the fissures had been missed while sounding and the cut blasted through into one, the results would have been disastrous. The material just above was known to be a very soft quicksand, and the proximity of the river would make it certain to flood the lower part of the station through the west end and the shaft there, and compressed air at a high pressure would have to be used to reclaim the whole tunnel.

At about 160 feet, sure enough, a fissure was located by the pilot holes, and the flow of water through the 1½-inch pilot holes indicated that the danger was real enough, but it was known that the river could not yet be reached. Pilot holes were sunk in a downward direction from the heading, and it was found that a drop in elevation of about 12 feet would permit the tunnel to be extended onward. A slope in the tunnel would not be particularly objectionable within certain limits, so an incline of about 70 feet in length was made, and the tunnel was resumed on a level a little over 12 feet lower. At a distance of about 270 feet from the shaft the pilot holes again ran out of the rock. This distance corresponded with a depth of about 15 feet of water at the low-water stage of the river, and pilot holes extended downward as before failed to locate rock at any available depth, so progress on this section was suspended awaiting the results of certain other work.

As considerable room would be required to make connections with the river, it was decided to terminate the intake and discharge conduits in separate headings, and as it was indefinite just how far it would be possible to go, a branch for the discharge was cut from the downstream side of the tunnel at a distance of 220 feet east from the shaft, to accommodate the discharge conduit, and it was run to a distance of 315 feet, which was plenty far enough, being under a minimum depth of water of 25 feet, and a chamber 12 feet wide by 20 feet long and 15 feet high was cut. This was a longer distance out and had a greater depth of water over it than the intake tunnel so far, and as the company needed condensing water badly, it was proposed that this side should be completed first, and part of the permanent discharge pipes used for a temporary intake, which would be sufficient for existing conditions by working the pipe at a high rate of flow, leaving the more numerous connections for the permanent intake to be finished so that the plant would have the benefit of the circulating water supply.

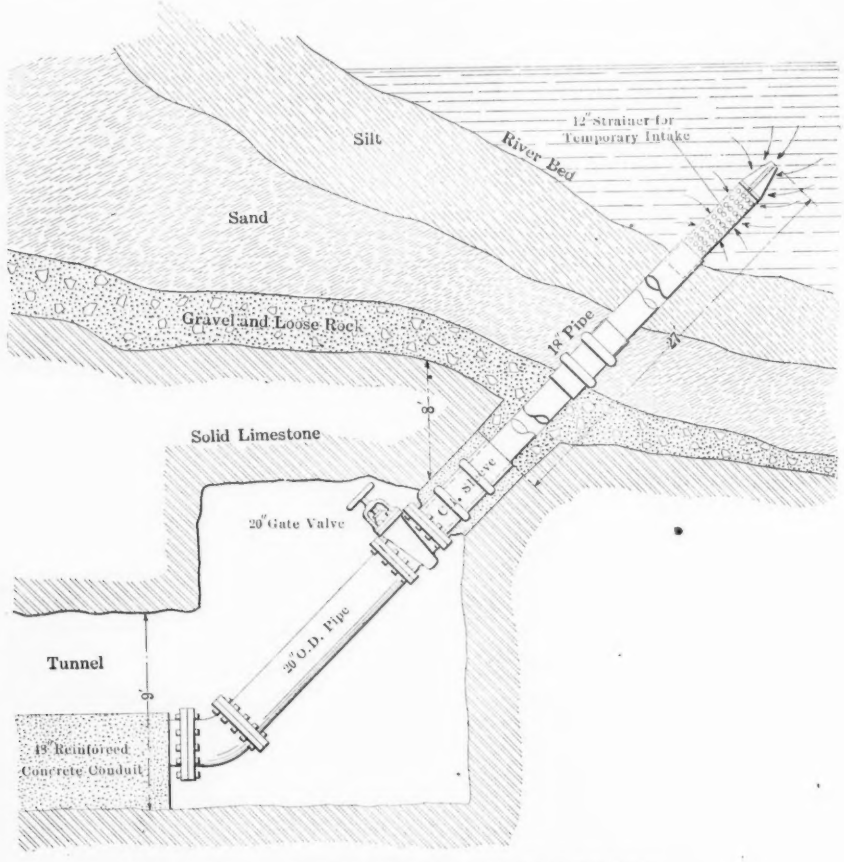


FIG. 3. SECTION THROUGH DISCHARGE HEADING

Some Experimental Work

While the chamber was being cut out to provide room to project the large pipes up through the rock, the scheme for doing the work was experimented with and perfected on a small scale in the idle portion of the intake tunnel, a bulkhead being built in the west end to guard against the results of a possible accident, and the connections made to the circulating pumps. For the permanent discharge, three holes about 4 feet center to center were carefully cut in the rock in the upper corner of the discharge chamber deep enough to receive specially made cast-iron sleeves a little over 18 inches inside diameter, which were inserted in the holes and blocked up to an angle of 45 degrees toward the river above, and cemented into the rock. Each sleeve had a flange provided at the lower end for a 20-inch gate valve, and after the cement had set thoroughly, the valve was bolted on. Then the remaining rock was cautiously removed through the sleeve until a mere shell was left, which was drilled full of holes by a man who was boosted up into the sleeve and furnished with a small air drill. The valve was then carefully inspected to insure its working freely, and a sluice gate also installed for use in case of accident to the valve. The small holes in one sleeve were next charged with a very small amount of dynamite in each, three trusty men were assigned to close the valve when the blast should be fired, and the small charges in one set of holes were fired simultaneously with electricity. A deluge of sand and rock and water followed instantly, and quick and sure work was necessary to get the valve shut. This required about 40 seconds, and on each occasion the better part of a carload of debris entered during that time, besides several feet of water.

The remaining distance from the roof of the chamber to the water in the river was about 20 feet, consisting of some 7 feet of rock and the remainder loose rock, sand and gravel. Three sets of 18-inch, outside diameter, pipes 27 feet long were provided, each set consisting of two sections 13 feet 6 inches long, which allowed the pipes to extend upward about 5 feet above the bottom of the river. The upper end of the first section of each pipe was closed by a loose, pointed cap, which itself was tapped out for a 3-inch jet, and this end was inserted into a stuffing box which was bolted on below the valve; the valve was opened, and the section 13 feet 6 inches long was forced up through the sleeve by hydraulic jacks. Considerable difficulty was experienced in getting the 18-inch pipes started, as the sleeves had settled full of loose rock and sand as soon as the opening was made through the solid rock, and it required a pressure of several hundred-thousand pounds to move the pipes at some points, nearly enough, in fact, to crush the pipes. The first section, with the cap on the end, was pushed up until the lower end was within a few inches of the valve and secured temporarily, and the second sec-

tion was fastened to it by an inside sleeve with rivets countersunk on the outside to form the flush joint necessary to pass through the stuffing box and sleeve. After the first section had been forced through the sleeve, progress was comparatively easy, and the second section was pushed clear through the stuffing box and valve and calked to a recess provided for the purpose in the sleeve.

The reinforced-concrete duct or conduit had by this time been completed to the end of the discharge branch, and a heavy nozzle for each of the 20-inch connections of the discharge branch. A 12-inch pipe, perforated with ⅜-inch holes to serve as a strainer, was projected out through each of the two 18-inch pipes on the upstream side, which were later to complete the discharge system, and connected to the 20-inch pipe, completing the provision for temporary supply.

Sand, Gravel and Coal in the Condensers

This having been done, the condensing plant was started, and the anticipated difficulties combated. The first of these was naturally the clogging of the 12-inch strainers. To overcome this, after some experimenting, an air tank about 4 feet in diameter and 12 feet long was put down as close as possible to the strainers, with a 3-inch pipe leading from it to each of them, and turned up toward the river inside the strainer. In this 3-inch pipe was placed an electrically controlled valve which was operated from the pump room, and which was so arranged as to open instantly to its full area when the circuit was closed. This, having such close connection with the large tank, gave an immense momentary rush of air when the valve was opened, and it was found upon trial that the strainers could be kept clear without closing them off or interfering with the vacuum on the condenser plant in the least, and a very small air compressor would serve to charge the tank.

The next serious trouble was the entrance of untold quantities of sand and gravel and coal into the condensers. The conduits were of much greater size than required for the capacity of the plant at that time, but it was reasoned that they would only fill with silt to a point where the increased velocity of the water would scour them, and anything more entering them would pass on through. It took some time to arrive at the cause of the sand troubling so seriously. It was at first suspected that it entered through a loose joint between the 18-inch pipes and sleeves, but this was rejected as impossible, as they had been calked iron to iron, and there was not space enough between them at any point for the coarser material to enter, even if they had not been calked at all. Then it was thought that a mistake might have been made in the reckonings and the pipes not extended far enough. They checked up perfectly, but a few random soundings in the river disclosed the cause. The river was on a rise of 25 feet or so, and incredible though it may seem, the bottom of the river had risen as well as the surface, being several feet higher than former soundings had indicated. The water carried an immense amount of solid matter from

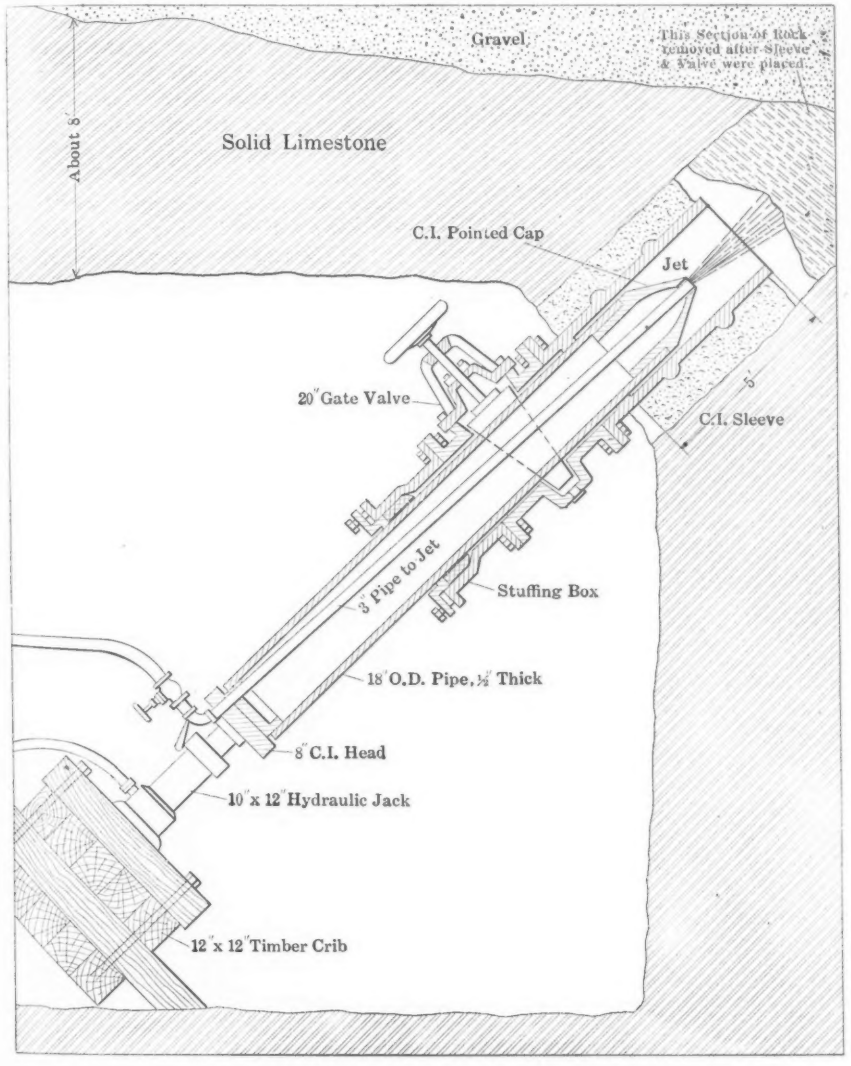


FIG. 4. PUSHING 18-INCH PIPE THROUGH RIVER BOTTOM

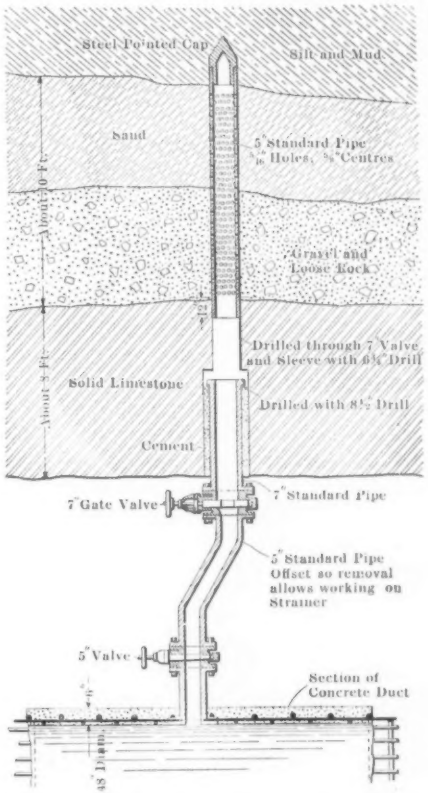


FIG. 5. DETAIL OF PERMANENT INTAKE STRAINER

to the river was cemented into the end, and substantial pipe bends provided to connect them with the valves. The loose cap was next pushed off from the pipe farthest down stream by putting a blind flange on the valve with a hole in it for a 2-inch rod to pass up through the pipe when the valve was opened, and the permanent connection made to the discharge conduit, leaving the other two connections to the river to be used for the temporary intake. The 4-foot intake conduit had been finished from the pump room to the point where the tunnel branched, and a 20-inch pipe was run from this to the end

regions above, and this was rolling and tumbling along the bottom deep enough to cover the 5 feet of projecting pipe and come well up on the strainers. The only remedy apparent was to push the pipes up farther, and to do so would invite danger from deep-draft boats at low water.

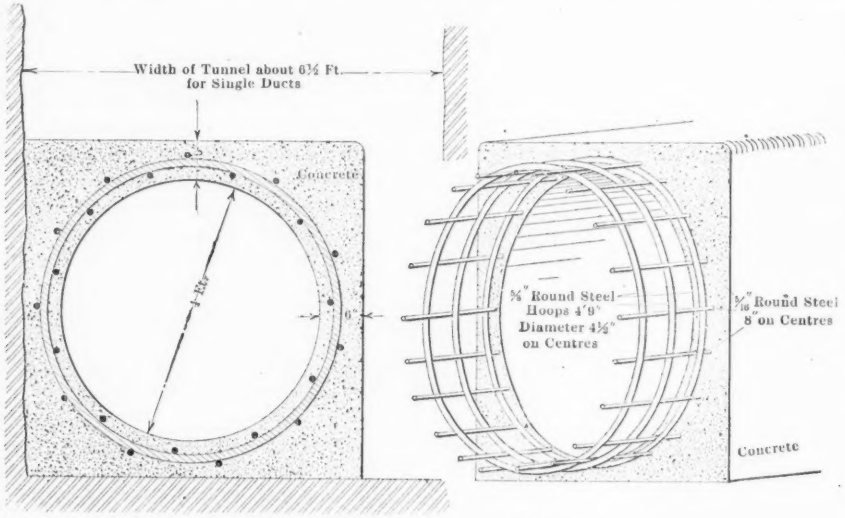


FIG. 6. SECTION THROUGH SINGLE DUCT

Operation of the condensers had to be suspended temporarily, and the case was so serious that the pipes settled full of sand when the pumps were stopped, before the valves could be closed, and the pipes had to be taken down and the sand and gravel washed and shoveled out of them. To relieve the situation a small dredge pump was located at a convenient point on the intake conduit, and the suction pipe of the pump extended to within a few inches of the bottom of the conduit. The discharge pipe of the pump was connected to the main discharge conduit, and the sand and gravel pumped over to it and carried out by the return water from the condensers. This disposed of the sand very effectually, but there was still a great amount of small pieces of coal and other matter having a specific gravity near that of water, which the dredge pump failed to get. The holes in the strainers were ⅜ inch, while the tubes in the condensers were ½ inch, and a disheartening number of twigs and such articles would worry through the strainers only to enter the condenser tubes in some different position and stick there. The abundant particles of coal were fairly diabolic in their perversity.

After a few hours' run, nine out of ten tubes would be stopped, and the vacuum could not be maintained. To obviate this, a strainer having 3/16-inch holes was devised, which was revolved by mechanical means in a closed cylindrical case in the discharge pipe of the circulating pumps, the strainer having a scraper to bear against it, and a drain pipe was provided to carry off all foreign matter removed by the scraper. It was found that when the river level lowered again, the sand stopped entering the intake, but steps were taken in the completion of the permanent intake then in course of construction to prevent the recurrence of such troubles. It was found upon thorough exploration by means of long drills in the rock surrounding the place where the intake-tunnel progress was suspended, that by going back a few feet and turning sharply to the right, the tunnel could be continued farther out under the river. This was done and the tunnel extended out about 75 feet, which brought it out to a point where the water was about 24 feet deep at low water, and this was considered ample.

Intake Terminated under Sand and Gravel of River Bottom

A permanent intake along the same lines as the temporary one would plainly be a continual source of trouble and expense. It was observed that great quantities of perfectly clear water came in through the pilot holes which merely went through the solid rock into the sand, and tests were made which indicated that strainers located in the sand and gravel under the river bottom would furnish an adequate supply if properly distributed. Accordingly the size of the strainers was reduced to 5 inches and the number greatly increased, and they were pushed out vertically through the roof of the tunnel about 10 feet apart, commencing at the nearest point where water-bearing gravel was found. When 25 of them were installed, a sufficient supply of perfectly clear water to supply the condensers was obtained, and the troublesome uncertainty of water supply was ended. Provision was made for replacing them should they become clogged or corroded, and also for connecting more when the demand on the station required it. It was found that a 5-inch strainer 10 feet long would supply between 200 and 300 gallons per minute at a difference of about 25 feet in hydraulic head. Each strainer is much like a deep well, but inverted, so it cannot fill with sediment. The water deposited a considerable amount of oxide of iron which formed a soft coating in the condensers, necessitating a thorough washing out of the tubes about once in each six weeks, but in over a year's operation the strainers have required absolutely no attention, and there has been no perceptible diminution of the flow from them.

At first sight it seems an absurdly simple proposition to supply a few thousand gallons of water per minute from an unlimited and ceaseless source like a river half a mile wide and 50 feet deep, but upon getting down to details, there are ten thousand and one problems, great and small, any one of which may turn the enterprise from success to failure or back again. The engineering reputations of countless careers have been won and lost in this field, and as it is usually impossible to foretell what obstacles will be encountered, each installation of this character must be carefully worked out to suit the individual case.

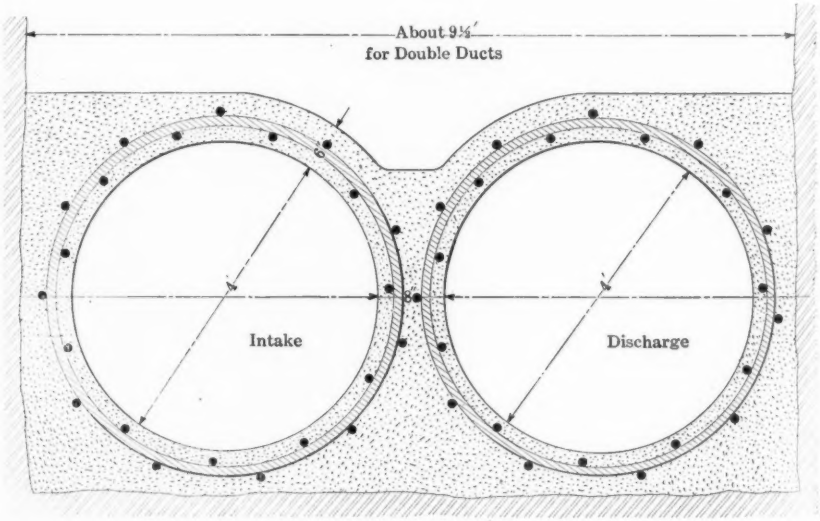


FIG. 7. SECTION THROUGH DOUBLE DUCTS

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Receiver Pressure

A study of the receiver pressure by engineers having charge of compound engines will well repay their time and effort. Undoubtedly compound engines having cylinder ratios of 1 to 4 or more, a cutoff in the high-pressure cylinder of not less than one-fourth stroke, and a high receiver pressure of about 25 pounds will result in a marked saving of steam, provided that the throttle pressure is not less than 120 pounds gage. Engines having cylinder ratio of less than 1 to 4 have invariably showed a greater steam consumption when the receiver pressure was raised, and engines having a very short cutoff and large cylinder ratios have also showed the same result. In the latter case, the expansion line of the high-pressure cylinder would drop below the receiver pressure, thus making an expensive loop.

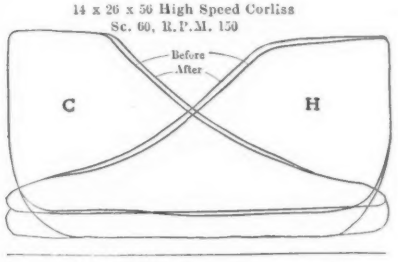


FIG. 1

The diagrams shown in Fig. 1 were taken from the high-pressure cylinder of a so-called high-speed Corliss, 14 and 26 by 30 inches in dimension, running at 150 revolutions per minute. The one marked "before" was taken with a receiver pressure of 8 pounds gage, the other with a receiver pressure of 20 pounds gage. The only change made in the latter was to lessen the compression. The load was obtained by means of a water rheostat, and was exactly the same under both conditions, as was also the steam pressure. One diagram is placed on the top of the other and clearly shows that in this engine, a high receiver pressure results in a later cutoff.

In the case of a 26 and 56 by 60-inch Corliss engine, with a cutoff in the high-pressure cylinder at 3/16 of the stroke, a raise of receiver pressure from 10 to 25 pounds gage resulted in no gain or loss. When the cutoff was lengthened to 9/32 of its stroke, obtained by putting on more load, the gain was pronounced, the cutoff invariably being earlier in the high-pressure cylinder. Again, in a 20 and 42 by 42 Corliss engine, an engineer, who I knew had certain facilities for keeping a steady load, reported a decided gain with a high receiver pressure. In all compound engines experimented with that had cylinder ratios of less than 1 to 4, the result of raising the receiver pressure showed a greater consumption of steam.

An easy way theoretically to determine whether there is gain or loss in raising the receiver pressure of any compound engine is to take a diagram from it and plot such lines on it as could reasonably be expected after the receiver pressure is raised. The diagrams shown in Fig. 2 were taken from a 24 and 48 by 48 Corliss, and the dotted lines show the lines which we will assume the indicator would describe if the receiver pressure were raised from 7.5 pounds to 25 pounds gage. We would probably realize 23 pounds as the initial pressure of the low-pressure cylinder, and as the expansion line *A D* follows the theoretical line *C D* so closely, we are justified in using *C D* to build our extension. The horsepower of the full-line high-pressure diagram is 756.58. The horsepower of the low-pressure diagram is 514.34. The total horsepower is 1270.92. Figuring now from our built-up diagrams, we have 610 horsepower from the high-pressure cylinder, and 692.36 from the low-pressure cylinder. The total is 1302.36 horsepower. This

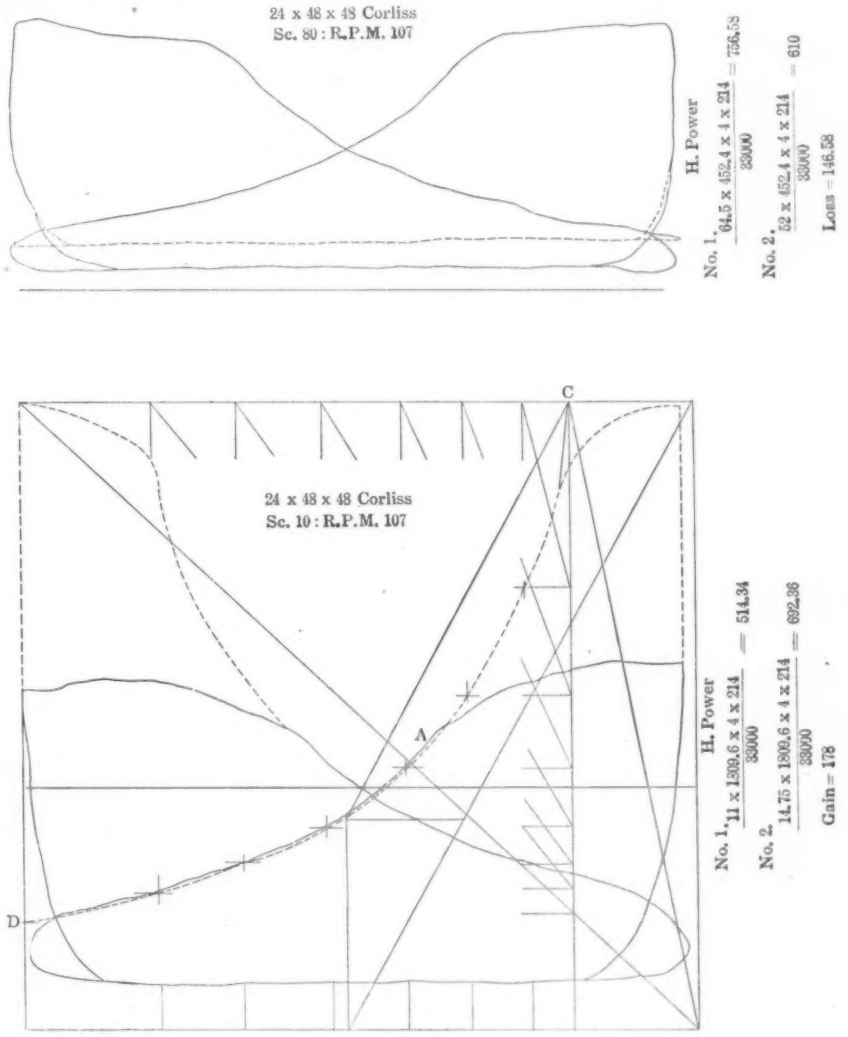


FIG. 2

means that we get 31.5 horsepower more from the same engine using the same amount of steam, by raising the receiver pressure from 7.5 to 25 pounds gage.

While we have endeavored to be fair in building up the diagrams shown, the result as obtained this way should not by any means be accepted as final, but should be verified by the indicator, as the size of the receiver has much to do as to whether this theoretical gain will be obtained in practice or not. I do not think that cylinder condensation enters much into the argument.

R. O. RICHARDS.

Framingham, Mass.

Repairs to a Turbine

The superintendent of a large manufacturing company using McCormick turbines of the horizontal-shaft type to generate power had trouble recently with the runner of one of them wearing loose through the bore, Fig. 1, and he could not key it tight. The runner was 33 inches in diameter, set on a 5-inch shaft, which fitted on a hub about 14 inches long. The bore of the runner had worn ½ inch larger than the shaft. These turbines set in a wheel pit measuring only 10 feet the narrow way, thus giving but little room for making repairs, and the runner cannot be removed from its case.

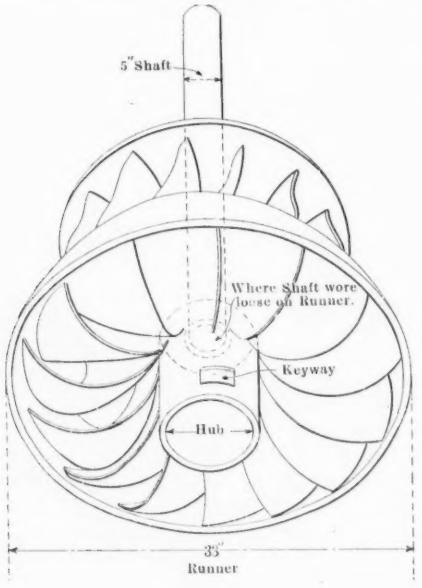


FIG. 1

The section in Fig. 2 shows how the machine was located. The case *A*, Fig. 2, caps the wicket which covers the defective runner as shown at *B*. This case is removable, as is the manhole in the retaining elbow *C*, which is 6 feet in diameter inside, allowing two men to work inside, but somewhat cramped. The problem was to tighten the runner on the shaft in some way without removing it. I suggested the following method of repair, requiring only four or, at most, five men: A collar or band of metal sufficiently wide to give proper bearing or, if necessary, two such bands to be cut and heated to a bright red in a bunsen furnace; they were to be cut to enable two men in the elbow case to slip them over the shaft so as to come inside the hub of the runner. The heat was to be made first and the bands sprung on like bracelets, and were to be thick enough to take up at least half the play of the hub where worn, and gripped tightly with tongs about the shaft while at bright red heat. By pouring water over the rings the sudden cooling would give an exceedingly tight shrink fit.

Next, long wedges were to be cut and drawn from metal, slightly tempered, and after shaping them to a flat bearing with a head left for a stop, they were to be driven in by sledging, to take up the remainder of the play between the shaft and bore of the runner. Two were to be driven simultaneously, in order to center it upon the shaft as accurately as possible. These keys being sledged in tightly with the flat side against the shrunken collar, would give greater binding power and the strain upon them would be lessened by the metal back of them.

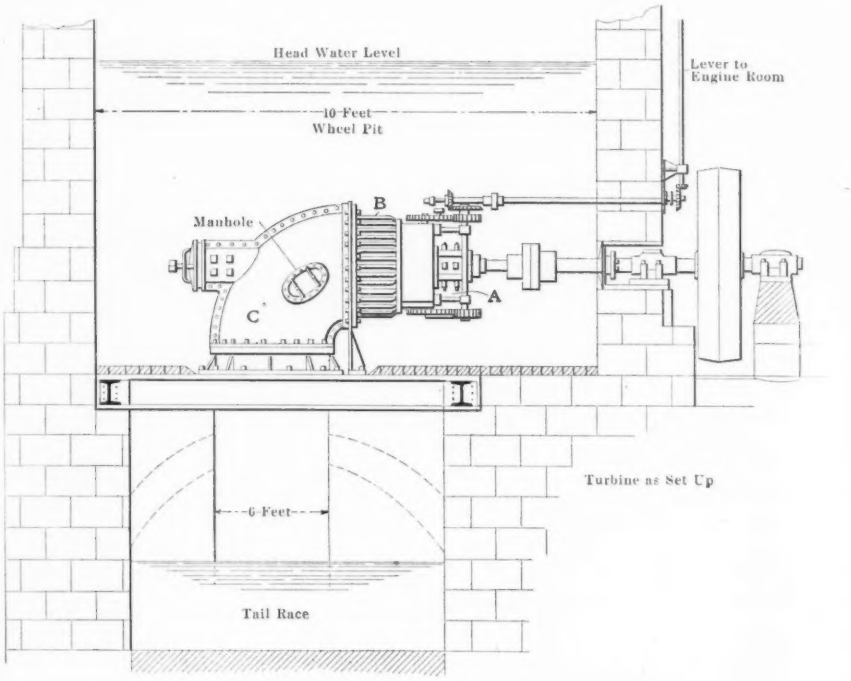


FIG. 2

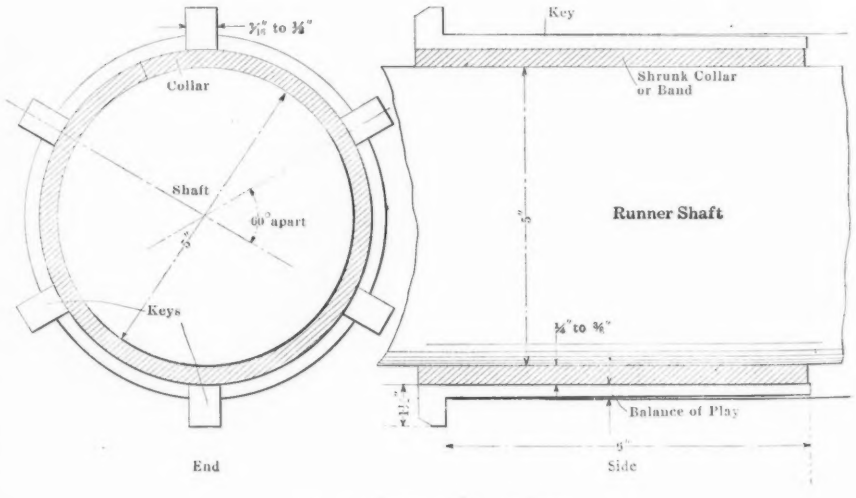


FIG. 3. SHRINK-FIT METHOD

Fig. 3 shows the method of making the fit.

The success of the repair was found to depend upon the tightness of the shrink fit and the number of keys. Six such keys were found not to be too much. The sketch illustrates the band, its position and the placing and shape of the keys.

F. A. MOORE.

New York City.

Another Case of Flickering Lights

I would like the advice of some one of your readers having had an experience similar to the following:

A plant consists of three units, two 50-kilowatt and one 25-kilowatt generators, all direct-driven. The average day load is about 100 amperes, but an elevator is running all day and the starting current is about 100 amperes. On account of the bad flickering of the lights when the elevator starts we have nothing but complaints.

To eliminate the trouble we have to run one of the 50-kilowatt machines all day at a loss, as the machine is only running at about one-fifth its rated load. Storage batteries have been seriously considered, but the idea was abandoned on account of the trouble, fumes and deterioration caused by them. The 25-kilowatt machine could be used, but the flickering of the lights caused by the elevator on starting is too great.

The only remedy we can now see is to use a small 10-horsepower machine to supply energy for the elevator and then keep the 25-kilowatt machine running at half load all day and independent of the elevator load.

Any suggestion from other readers will be greatly appreciated.

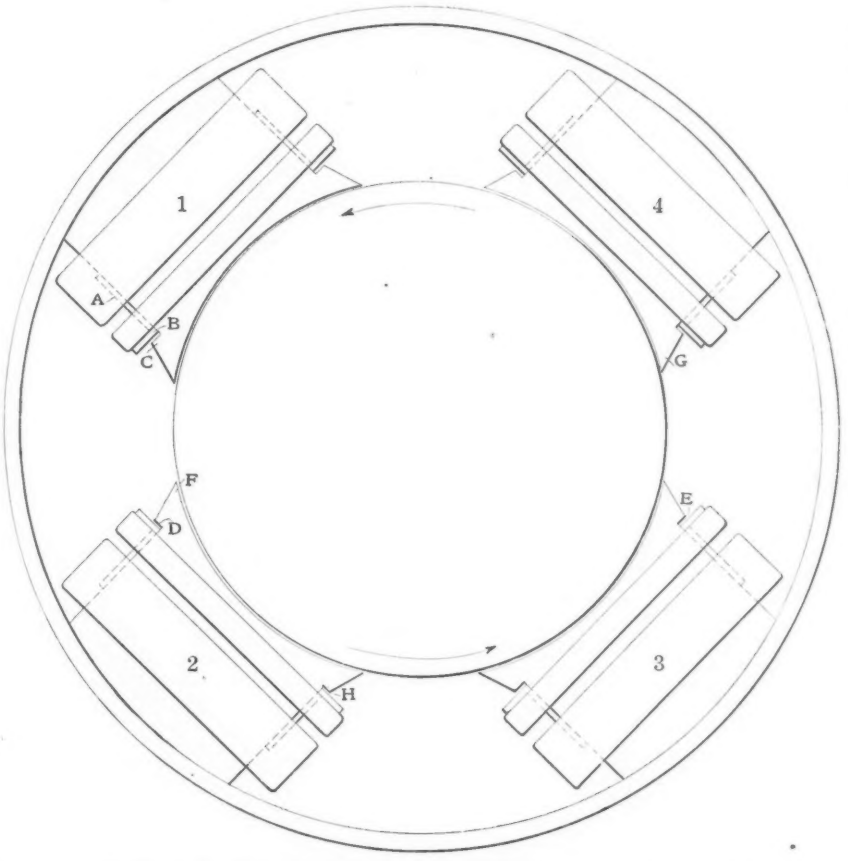
M. G. Carrol.

New York City.

Motor Troubles

In the plant where I am employed there is a 15-horsepower direct-current, 220-volt compound-wound motor, operating on 250 volts. This motor is belted to a triplex pump which is used for pumping water into an open tank on the roof, the head being about 100 feet. It is automatically controlled by a float operating a starting device and runs about 5 minutes out of every 20 and keeps this up 24 hours every day. Everything works perfectly, and has never given a particle of trouble during the five years it has been in operation.

Something strange happens to this motor once in a while. The field coils are held in position on the core by cast-iron strips 3/16 inch thick and 1 inch wide extending up between the inside of the coils and the outside of the core, as shown at *A*, and are bent at right angles at *B*. Each pole piece has four strips, two on each side, only two are shown in the cut. They are just set in and by resting on the shoulder of the core at *C* prevent the coils from slipping down.



SHOWING THE ARRANGEMENT FOR HOLDING THE FIELD-MAGNET COILS

About one year after this motor had been installed one of these strips broke off at *D* and wedged itself between the armature and the pole piece, which threw out the circuit-breaker and prevented the motor from starting until a search for the trouble was made, when the piece was found as stated. I heard a hissing sound coming from the motor one morning, some time later, and on examining it I found another piece broken off at *E*. The piece was found resting on top of the pole piece No. 2 and was rubbing against the armature, being held there by the magnetic force.

Since then three more pieces have broken off; one at *D*, one at *E* and one at *H*, making in all five pieces, two on the upper side of No. 2 coil at *D*, one on the lower side at *H* and two on the upper side of No. 3 coil at *E*.

This motor has not been disturbed or moved since it has been installed, and gives no trouble whatever except for cleaning and oiling. The motor runs 850 revolutions per minute and is not overloaded.

I would like to know what breaks these lugs off. It will be seen that the broken ones are all on the lower pole pieces and there is no weight or strain on them, the coils holding themselves in position by their own weight. The only strain on them is quite a strong magnetic pull in the direction of the arrow while the motor is running.

C. S. Norman.

Detroit, Mich.

Detecting Leaks with the Indicator

This subject may stand a little more discussion, as I notice in a recent issue that the indicator is again ignored, so far as its value in detecting leakage in engine valves and pistons is concerned.

In some cases it is proper to remove the cylinder head and test for leakage with steam pressure; however, many engines are operating under practically continuous service conditions, where time is limited.

It may appear to some engineers that it is time lost trying to detect leakage with the indicator, and so it may be if the leakage is so slight that it neither amounts to dollars nor cents nor affects the efficiency of the engine. However, it has been my experience with three different engines to detect leakage with the aid of an indicator, due to the snap ring being broken and the consequent leakage of steam past the piston. The distortion of the diagram in each case being so visible on the admission, expansion, exhaust and compression lines that it could hardly escape recognition by the most intelligent technical graduate or the most skeptical "old timer." The indicator may be relied upon to detect leakage as well as other errors, and in my own practice I have always been able thus to detect and rectify serious leakage prior to it being detected on the cost sheet by the manager.

It is not customary to use the indicator for the purpose of testing the tightness of pistons and valves, but while indicating the engine for any purpose, the indicator will detect all leakage of any consequence.

W. C. Light.

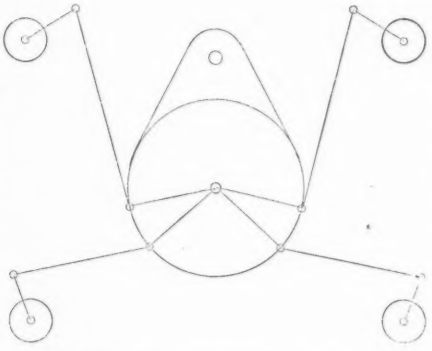
Painesville, Ohio.

Setting Steam Eccentrics

W. E. Crane seems to have a grouch against the long-range cutoff Corliss gear, judging from his letter in the August 18 number of POWER AND THE ENGINEER. His principal grievance seems to be that he cannot handle the engine with the starting bar and cannot warm his engine up, and he thinks if his steam eccentric were set at 90 degrees instead of 60 degrees he could do both and be happy. As it is now, he seems quite unhappy. But could he handle the engine with the starting bar and reverse or back up at will if he set his steam eccentric ahead from 60 degrees to 90 degrees? Of course, his engine has two eccentrics and two wristplates, and when he threw his steam wristplate over with the starting bar to reverse, the exhaust wristplate would be set to go ahead and the engine would not reverse unless he had a hook on the exhaust wristplate, too, and unhooked both wristplates and worked them together while operating with the starting bar; but I knew of one such design where the engineer who had been used to operating a single-eccentric engine neglected to unlock the wristplates before he threw in the hooks. The result is easily imagined.

Most two-eccentric long-range cutoff Corliss valve gears are arranged as shown in the accompanying sketch, from which it is obvious that with this design both steam and exhaust valves open on each end when the two wristplates oscillate in the same direction. This valve gear, therefore, could not be operated with the starting bar by locking the wristplates together.

In the last paragraph, at the bottom of the third column on page 280, I take it that the number 60 is a typographical error and should be 90 [it is a typographical error — EDITORS], but Mr. Crane's conclusions are entirely wrong in this paragraph. If I understand the statement: "Setting all wristplates vertical, as the steam valves have 1/16-inch lead and the exhaust ⅛-inch, by simply opening the throttle the steam blows through both ends of the cylinder," it means that the steam valves are open on each end 1/16 of an inch and the exhaust valves are open ⅛ of an inch on each end. Of course, he can set the steam eccentric at 90 degrees, give the valves 1/16-inch lead and have the valves remain hooked up when the governor is at its lowest position and have the steam blow into the cylinder at both ends, but he will have the worst kind of a long-range cutoff condition; however, it does not follow that giving the exhaust valves ⅛-inch lead will give an opening of ⅛ inch on each end when the exhaust wristplate is in the vertical position. The term "lead" as applied to the exhaust valves has no meaning. If the exhaust valves are open ⅛ inch on each end when the wristplate is in the vertical position, there will be earlier release and later compression and the valves simply show negative lap, not lead. If the valves are set line and line, with no opening or lap when the wristplate is in the vertical position, the release and compression, barring the angularity of the connecting rod, are equalized, no matter how the exhaust eccentric is set, and if the exhaust valves have lap when the wristplate is in the vertical position, there will be later release and earlier compression. If the steam eccentric is set at 90 degrees with the steam valves open 1/16 inch on each end when the wristplate is in the vertical position, the steam will blow through into the exhaust on each stroke alternately on either end when the cutoff toes fail to release, whether the exhaust valves are line and line or have positive or negative lap, and Mr. Crane would have the same conditions as in the design he so vigorously condemns.



HOW MOST TWO-ECCENTRIC CORLISS VALVE GEARS ARE ARRANGED

R. A. NIVEN.

Brooklyn, N. Y.

In the article, "Setting Steam Eccentrics," which appeared in the issue of August 18, Mr. Crane gives some of the disadvantages of the compound engine, disadvantages which to the layman or even the inexperienced engineer, may at first sight appear to be serious.

That "there is no way to tell when running, nor when stopping or starting, without going all over the engine," whether it is designed for short- or long-range cutoff, is far from being correct.

Nine times out of ten the position of the valve-rod pins on the steam wrist plate will indicate short or long range. In determining the position of these pins for either case, it is only necessary to remember that on the short-range engine the pin must complete about one-half of its total travel in order to remove the lap of the steam valve. This, with a knowledge of the amount of lap generally used on different sizes of cylinders and the chisel marks on wrist plate and bracket should prove sufficient for determining the range of cutoff.

Many engineers can distinguish at a glance between long- and short-range gear by noting the relative position of the wrist plate, valve, valve-rod pin and the valve arm. This, of course, requires some knowledge of the kinematics of the Corliss valve motion.

Another method, and one better suited to the operating engineer, is to unhook the steam reach rod, throw the wrist plate over to one of its extreme positions and hook on the valve arm. After slightly opening the throttle valve, slowly return the wrist plate and note when steam enters the cylinder. If the machine is short-range this will occur when the wrist plate has reached, or nearly reached, its vertical or mid position. In the long-range setting the wrist-plate pins are so located that a given amount of motion of the wrist plate will produce a corresponding amount of the valve arm, or nearly so. The steam valves being lapped an amount sufficient for seal only, the valve will open long before the wrist plate reaches its mid position.

Resorting to the steam test described above, it will be found that the steam valve opens when the wrist plate has completed from one-sixth to one-fifth of its total travel. This simple test requires but two or three minutes' time, much less than would be required for "going all over the engine."

With the engine in motion even it is a simple matter to distinguish between long- and short-range gear.

In the short-range the wrist-plate pins, both steam and exhaust, move in the same direction around a circle during a single stroke of the reach rods. In other words, the two wrist plates are diametrically opposite, or nearly so, at all points of their travel. With the long-range gear this is not the case; the wrist plates at one time moving in the same direction around a circle, and at another moving in opposite directions.

Mr. Crane's statement to the effect that with the long-range setting the engine cannot be worked by hand, is also far from being correct.

It is true that with the 60-degree eccentric setting both steam valves are open about half the port width when the wrist plate is in mid position, but this condition is no more disadvantageous than that of the 90-degree setting advocated by Mr. Crane, where the steam valves are open 1/16 inch when the wrist plate is in the same position. In both cases one steam valve must increase its opening in order to close the other and in no position can both steam valves be closed while hooked up.

By raising the governor spindle and thus advancing the knock-off cams, the amount the steam valve must travel to the point of release can be lessened a considerable amount and, in consequence, the corresponding wrist-plate motion. With this reduced wrist-plate motion, an engineer with a little practice can readily operate a long-range gear by alternately

hooking up and releasing. If, by blowing steam through a cylinder with the steam eccentric set at 90 degrees, the wrist plates vertical, and the steam valves opened 1/16 inch, one can "warm up a cold engine quickly and thoroughly," why cannot the same result be obtained with the eccentric set at 60 degrees, the wrist plates vertical and the steam valves opened an amount equal to one-half the width of the port?

C. BAQUET, JR.

Spotswood, N. J.

Evaporation Tests of Boilers

On page 366 of the issue for September 1, I note a question by F. H. Neely as to the evaporation tests of boilers. He fails to give the type of superheater installed with these boilers and it seems that, to a certain extent, opinion should rest upon this point. If the superheater is situated in the boiler in such a manner that it uses space which would otherwise be used as heating surface proper, then the boiler manufacturers would be correct, and the heat used in superheating the steam would have to be considered.

An appliance of this kind, called the "Schmidt" superheater, is being used to some extent in locomotive boilers. With this type, the saturated steam is carried through small tubes situated inside of large flues which in turn occupy space regularly used for the usual boiler tubes. Part of the gases from the furnace is thus used directly for superheating, and this being the case, a fair test must include this heat.

On the other hand, if a boiler of the regulation pattern has a superheater so located as to use the heat of the fire only after it has passed through the boiler and which may or not be cut in for use as occasion requires, then it would seem as if the test should include only the boiler heating surface.

However, before any blame is attached to the manufacturers, it should be noted whether or not the specifications cover the superheater with the boiler as a unit, and judgment should be passed only with this fact in view. It would seem, however, that in no case could the heat absorbed by the steam in process of superheating be properly considered as heat used in evaporation.

L. F. WILSON.

Chicago, Ill.

In the article under the above heading, by F. H. Neely, in the September 1 issue, he asks if there has been previous discussion of this matter. I do not remember having seen any, but on several occasions I have discussed the question when considering what boilers should be installed in new plants, or in plants that were to be increased in capacity.

Mr. Neely does not say whether there were superheaters installed with the boilers he tested or not, but from what he did say, I presume there were.

It happens that in all of the cases I have been connected with, we figured to superheat the steam 100 degrees, and the boilermakers claimed that superheating the steam 100 degrees would reduce the evaporative efficiency of the boiler from 5 to 7 per cent., and in all cases they inserted a statement covering this point in their contract. The percentage of difference can readily be figured when you know the amount of superheat that is added to the steam.

When we consider the difference between an economizer and a superheater, we see that one is very different from the other, as the economizer is used only to absorb heat that would otherwise be wasted, while the superheater is used to raise the temperature of the steam a definite amount above the temperature due to the pressure.

To increase the temperature of the steam 100 degrees in a superheater connected with a boiler that is properly efficient, could not be expected, even if the superheater were placed beyond the boiler where it would carry on the work of the boiler as suggested, as the gases should not leave the boiler at a temperature high enough to do it. I have many records of tests where the flue-gas temperature is much less than 100 degrees above the steam temperature; consequently, it would not do to place the superheater beyond the boiler.

The superheater must be located where it will be sure to receive heat enough to give the desired increase in temperature; consequently, the heat that it utilizes is heat that the boiler would otherwise use itself and must be accounted for in figuring the results of a test for evaporation.

N. J. PEAD.

North Adams, Mass.

Referring to F. H. Neely's remarks on page 366 of the September 1 issue, in regard to figuring superheat in connection with boilers, I wish to say that a boiler working under 175 pounds steam pressure has a temperature due to the pressure of 377.5 nearly. The flue gases leaving the boiler should be from 100 degrees to 150 degrees above the steam temperature for good results at boiler rating, or say an average of 500 degrees flue temperature.

Under these conditions a superheater placed back of the boiler would have to be of such large heating surface that the cost would be prohibitive. Furthermore, it would be impossible to raise the steam temperature as high as the gas temperature, or even close to it in general practice, because the steam must absorb its heat from the gases and the temperature of the gases would be lowered by the process; consequently, if enough superheating surface could be provided (which is not practical on account of the cost), it would only be possible to get a superheat of, say, 50 per cent. or less from 500-degree flue gases and 150 to 175 pounds steam pressure. Even then the gases would leave the superheater at practically the same temperature as the steam, which is not practical.

The proper place to put a superheater is after the gases have passed over about one-third of the heating surface of the boiler. The heating surface of the superheater can then be reduced so that the cost of the superheater will not be excessive.

After leaving the hot heating surface of the superheater the gases will be further reduced in temperature by coming in contact with the cooler heating surface of the remaining two-thirds of the heating surface of the boiler; or, putting it another way, the lowest temperature of gases should pass over the lowest temperature of heating surface in order to absorb the heat quicker, which is necessary in regular practice.

The writer thinks that if Mr. Neely had put the question of figuring superheat in connection with the boiler up to the manufacturers before the installation of the boilers, they would have told him that any heat put into the steam cannot possibly be put into the water also, so that the extra coal required to superheat the steam cannot be charged to the boiler, and in figuring the two together, the factor of evaporation must be figured from the steam temperature leaving the superheater.

The principal boiler manufacturers state their position clearly, and I refer the reader to Babcock & Wilcox company's book, "Stirling," page 93.

In regard to the heat absorbed by the economizer, this is not credited to the boiler. The temperature of feed water should be taken between the economizer and boiler and the heat absorbed by the boiler figured from that temperature. The economizer taking feed water from the heater or some other source will, of course, be of much lower temperature than the boiler, and will therefore absorb the low temperature of the gases leaving the boiler with a reasonable amount of heating surface, which would not be the case with a superheater.

The whole question is summed up in this: A pound of coal contains a certain number of heat units; if we put 7 per cent. of the available heat units into superheating steam, there must be 7 per cent. less heat units for the water in the boiler to absorb, and the evaporation will be 7 per cent. less with a superheater than without it; but it must be borne in mind that the steam will be increased in efficiency more than the 7 per cent. when used in the engine.

C. H. JOHNSON.

Allston, Mass.

Steam Loop Trouble

F. H. Beard, in the August 18 issue, asks if any of POWER AND THE ENGINEER readers ever operated a "steam loop" that worked successfully. I have operated the steam loop on three different occasions and have never known it to work otherwise than successfully. This is probably due to the fact that they were designed correctly. In the operation of the steam loop the entrained water, or water of condensation, as the case may be, is carried over the loop in the form of a spray or thin film along the sides of the riser. It then passes over the loop to the horizontal and down the drop-leg, where a column of water of enough weight forms to overbalance the pressure and thus returns to the boiler.

It has been estimated that the horizontal pipe should be placed 3 feet high for every pound difference in pressure between the boiler and the point of drainage. That is to say, if the pressure in Mr. Beard's dryer is 10 pounds less than the boiler pressure, his horizontal pipe should be 30 feet above his blowoff pipe. I would suggest that he find the difference in pressure, and if it is much different, to raise his horizontal pipe accordingly.

The loop was never intended to handle water in bulk nor in large quantities, for water should not be allowed to accumulate in the dryers and expect the loop to carry it off as a trap does. When we start our loop after having it shut down for repairs to piping or packing valves, we first blow all the water into the sewer, until steam comes and then open it to the boilers. In Mr. Beard's sketch there is no way of blowing out his loop, and I would suggest that he tap in a pipe with a valve, as at *A* just above the check valve, and another at the bottom of the riser where the ell is placed, as at *B*. One reason for blowing out is that the air accumulates in the horizontal pipe, thus preventing the loop from working; the other is to get rid of any liquid mass which may have accumulated at the base of the dryers or heaters. With these changes there is no reason why Mr. Beard's loop should not work.

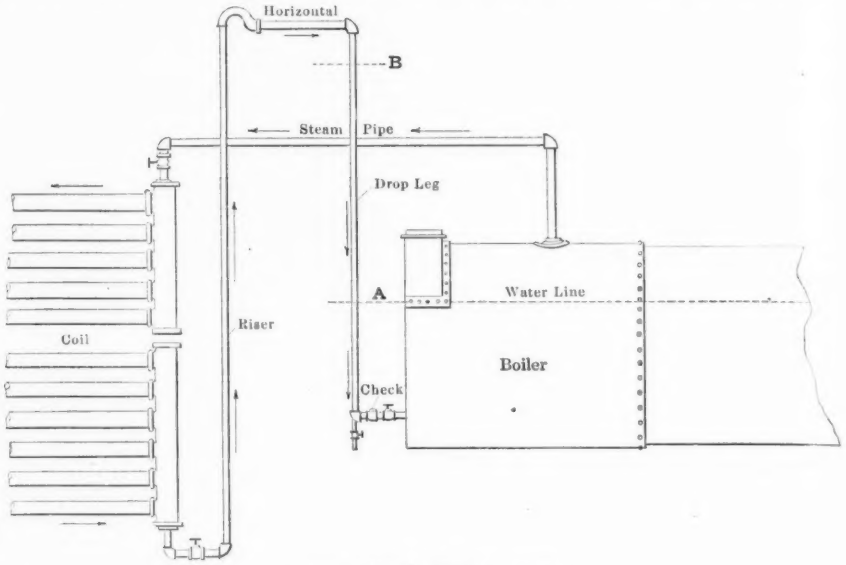
JOHN J. MAHONEY.

N. Cambridge, Mass.

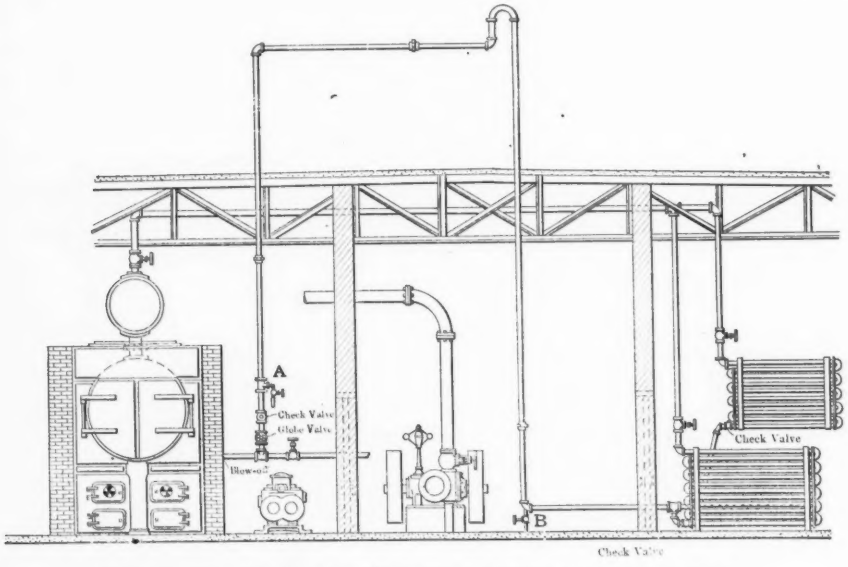
Regarding the steam loop which gives F. H. Beard trouble, I will say that there may be several causes why it will not operate.

The steam loop consists of three parts, the riser, the horizontal and the drop-leg. The pipes vary in size from ¾ to 2 inches and their proportions and immediate relation make up the capacity and strength of the system.

There is one system now in daily use lifting the condensed water over 39 feet and another lifting it over 63 feet. The strength of the system is increased by its length and hight, the only limit to its operation being the practicability of erecting the necessary drop-leg, the hight of which depends on a difference in pressure.



MR. DAILY'S STEAM LOOP



ILLUSTRATING MR. MAHONEY'S VIEWS ON THE STEAM-LOOP TROUBLE

Referring to the illustration, let us assume that all the valves are open and full boiler pressure is being admitted throughout the steam pipe, coil and loop. If the pressure were exactly uniform throughout the whole system the water in the loop would stand at *A*, on the same level as the water in the boiler, but the pressure is not uniform throughout the system, but is steadily reduced from the moment it leaves the dome. This reduction in pressure is due, in part, to condensation and in part to friction. The pressure may be intentionally reduced at the valve on the coil, and a reduction necessarily results from condensation within the coils. A still further reduction takes place through the loop so that the lowest pressure in the whole system will be found at *A*, the point in the loop farthest from the boiler, in the path of the flow of steam.

It is known that water of condensation invariably works toward and accumulates in a "dead end." This is because the pressure is lower at the "dead end" than at any part of the system, and there is a constant flow of steam toward the point of least pressure, which flow continues as long as condensation goes on. This sweep of steam carries all the water formed by condensation along with it, in the form of small slugs, or pistons of water, which completely fill the pipe at intervals, traveling rapidly toward the dead end.

In practice, water will be carried over by the loop and accumulate in the drop-leg until it rises to the level *B*, which would balance the difference in pressure. As the loop will still continue to bring over water, it follows that as fast as slugs of water are deposited by the steam on

the top of the column *B*, it overbalances the equilibrium and an equal amount of water is discharged from the bottom of the column through the check valve into the boiler.

I. P. DAILY.

Lemonville, Mo.

Answering F. H. Beard's call for help in his steam-loop troubles in the August 18 issue, I submit the following: I have a steam loop draining over 2000 square feet of radiation at 15 pounds boiler pressure, and working perfectly. Mr. Beard does not say how much radiation he has in the two radiators, so the fall in pressure between the boiler and the loop cannot be estimated.

It would be well to remove the check valves from his radiators, and make as few and as easy turns as possible between the radiators by using 45-degree ells in place of 90-degree if possible, and if the radiators contain more than 1500 square feet, make both upright pipes of the loop 1¼ inches in diameter and the horizontal pipe 2½ inches (3 inches would be better).

Then tap the top of the elbow on the upper end of the drop-leg and put on a steam gage and find the difference between the boiler pressure and the pressure at this point.

This drop-leg must be high enough to contain water enough to overbalance the difference in pressure shown by the gages. Then remove the gage on the loop, and run a small pipe from this tap to the boiler room, or any convenient place, and put on a small air or vent cock. Leave this vent cock open a very little and I am sure the loop will work perfectly.

This vent may need to be fully opened in starting the loop, but can be almost entirely closed after the circulation has started.

A. D. ELLISON.

Three Oaks, Mich.

A Couple of Things Worth Knowing

Some years ago I got stuck for a gasket for one of my glass-body oil cups. I had no more cork gaskets, and I found that any ordinary rubber sheet packing would soon dissolve and form a gum that not only smeared the glass but clogged the feed. As a last resort I tried gaskets cut out of the cover of a paper box, and I found them equal to cork, and have since used them for this purpose with entire satisfaction.

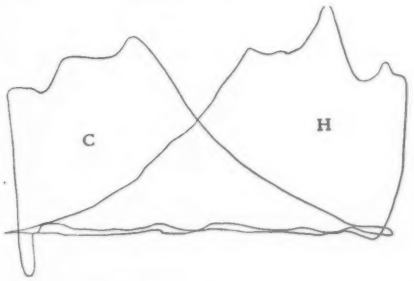
When doing a job of babbitting use fireclay; it is better than putty, as when the hot babbitt comes against it, it will harden and not give way, where putty will soften, and if the babbitt is heavy, putty is apt to give way.

J. R. MORTON.

Detroit, Mich.

Why the Receiver is Noisy

In reference to the article on page 1040 of the June 30 issue, "Why is the Receiver Noisy?" I would suggest that Mr. Norton try weaker springs on the discharge valves of his compressor.



DIAGRAMS FROM AN "IMPERIAL" TYPE 10 COMPRESSOR

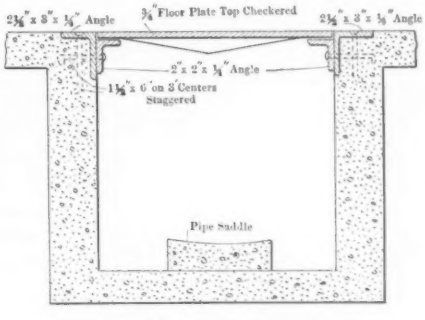
The diagrams here shown were taken from an Imperial, Type 10, 11x15x12 compressor, running at 160 revolutions per minute. On the high-pressure side the valves on the head end are shown to open and close three times in one stroke. Both ends of the diagrams were the same until a very weak spring was placed in the crank-end valves, which stopped the hammering of the valves and the receiver.

L. T. STUART.

Salt Lake City, Utah.

Pipe Trench

The details of a concrete pipe trench and the method of holding the trench covers are shown in the accompanying illustration. The long leg of a 2½ and 3 by ¼-inch angle iron is riveted to one leg of a 2 and 2 by ¼-inch angle. When the forms for the concrete work are set, the angles are placed in position with the anchor rods projecting into the space to be filled with concrete. When the concrete sets, the angles are held securely and provide an extremely neat and durable rest for the trench covers. The latter



DETAILS OF PIPE TRENCH

are of cast iron, ribbed on the bottom and checkered on top.

It may be of interest to some to know that this checkered surface may be obtained by rubber sheeting nailed on the pattern, or by wood prepared especially for this purpose by a concern making a specialty of this work.

A concrete pipe saddle is provided at the bottom of the trench to raise the pipe joints enough above the floor to make them accessible.

GEORGE W. MARTIN.

Pine Bluff, Ark.

Lightning Protection for Tall Chimneys

In reply to H. R. Hadfield's criticism of my article, I would say to Mr. Hadfield, who wishes to know what function the sharp platinum performs when placed at the end of a lightning rod, that platinum was specified for the reason that it does not change in the air or by acids, and always has a high luster and remains bright. It has a high melting point and can only be melted in the flame of the hydrogen blow pipe. It also resists the action of most substances. Platinum is nearly as good a conductor of electricity as copper, as it has a low resistance and a high conductivity. Copper, however, becomes covered with a green layer of carbonate of copper and does not stay bright.

The Washington monument at Washington, D. C., has a platinum tip, and as it has been struck numerous times, it has demonstrated that a platinum tip is the best possible point for a lightning rod.

Experience has shown that electricity travels through the best conductors, and if a stack is equipped with metallic conductors, lightning will travel through these instead of striking the stack. If these rods terminate in points they also exercise a preventive influence by enabling the clouds and earth to gradually exchange their opposite electricities.

A badly constructed lightning rod is a source of danger instead of protection, and the following should always be borne in mind: The connection with the ground should be continuous, the conductor of ample section, the earth contact good, and the extreme point should be sharp.

If a platinum tip proves too expensive, the copper can be pointed and the point gilded. All bends in the cable and connections thereto should be long-sweep bends, so that they should not give any trouble.

Copper trolley wire can be used for conductors, as they can be obtained in one-piece lengths. I do not agree with Mr. Hadfield that a copper ribbon is preferable to a cable, as the ribbon is of thin section and there are chances of faulty connections, which would render the conductor a dangerous thing to have about. Another thing, a brick stack is of such prominence that the lightning rods should be placed in such a manner as to give a pleasing appearance.

A. RAUCH.

Pittsburg, Penn.

Finding Steam

I can heartily indorse William Longstreet's contribution on "Finding Steam" in which he states that "traps are 'trappy.'" Before installing a number of old traps in my plant, I asked the "powers that be" what condition they were in, with a view to overhauling them (I was new on the job), and was assured that they had already been thoroughly overhauled. They were installed, therefore, and ran for several months.

We weigh our coal and meter the feed water. The traps are on heater coils used in a manufacturing process, and as the heaters are in operation when the rest of the plant is idle it was easy to determine the quantity of water, or steam, used by them, which seemed abnormally large, and so an investigation was decided upon. The result was a saving of from 1200 to 1600 pounds of coal per day. This is a very fair percentage of a daily consumption of six tons of coal. This waste was not due to worn valves, but because the "needles" had not entered the seats or openings, but were outside of them, leaving the traps wide open.

A peculiar coincidence is the fact that a day or two after fixing the traps I read "Finding Steam" in POWER AND THE ENGINEER. Can anyone explain the coincidence?

R. McLAREN.

Berlin, Ont.

[The explanation is simple. POWER AND THE ENGINEER covers the field so completely that there are few engineering experiences not covered during the year. —EDITORS]

American Gas Engines as Good as Any

In the article of J. C. Miller, on page 106 of the July 21 issue, the remarks in regard to the certainty of steam power are to the point. I think, however, that Mr. Miller does an injustice to American engine builders where he mentions that his conversion to gas power was set on foot in the first place by a producer and engine of English manufacture, and finished by the examination of other plants of English and German manufacture. Later, he adds a few words in praise of gas engines of English manufacture, which might lead the novice to suppose that it was necessary for prospective purchasers of such plants to go abroad to obtain satisfactory outfits.

I believe that such a procedure is unnecessary, and that both producers and engines can be purchased in this country which will give as good results and be as easily operated as those of foreign build.

I am well aware of the fact that many of the plants now being built in this country are largely experimental, and that it is wise for the buyer to spend time and money in investigating thoroughly before investing in an outfit which may be a source of trouble and expense instead of profit.

My experience also plainly proves that American engine builders are fully capable of building producer-gas plants, and are doing so, and that it is clearly unnecessary to look to foreign builders for apparatus which will meet the most exacting requirements as to reliability, speed regulation, and ease and economy of operation, and, to all appearance, durability.

H. B. MESSENGER.

Federalsburg, Md.

Compression

Many intelligent engineers have gone over the matter of compression and I have read with much interest the suggestions of running without lead or compression. The reason I am touching on these points is because I am a sound believer in low compression; as some years ago, when designing and testing some economical four-valve engines, their performances were being looked over by a good engineer who remarked that I favored low compression. I said I did, but was not an advocate of no lead or compression under the present constructions of our engines, as it was impossible to run as quietly and on as little fuel as with compression used in moderation.

Some engines can be run with less compression than others, but there must be compression enough to stop the moving parts, and the amount depends upon the construction of the engine and its piston speed.

Now, as lead goes hand in hand with the compression, would it be wise to say that we can reach the same economy by a diagram with a leaning admission line as the one having a vertical line? I am in favor of a slight deviation from a vertical admission line on medium-speed engines toward the movement of the engine. All engines do not require the same lead as is the case with the compression. We could possibly build an engine using very slight or no lead by increasing our admission the real length of our port opening.

Not long since, the writer redesigned some large engines that had recently been built; these had a piston speed of 900 feet, so you can see the necessity of wide port openings, and not a deep port. On one of the high-pressure cylinders, carrying 180 pounds, I made a multiple-balanced valve having a movement of 8 inches. I mention this travel, as those fully versed in valve gear will appreciate the sharpness of its port opening compared with the travel of a 36-inch cylinder. This valve opened four edges 14 inches each in a 16-inch cylinder. Almost a square setting did the work and this was a case of putting reasonable theory into practice. The results were entirely satisfactory, but had this cylinder been designed as many are, the lead would have had to be excessive owing to the speed of this piston. Of course the high pressure increased the velocity of the incoming steam, but I must confess that we had to use compression, and being a vertical engine, we had to use the most on the downward movement, as we had weight and gravity to overcome.

I expect we could lower the compression and lead on many of our engines and save fuel, but I do not believe in putting a "springboard" under the flywheel every time the crank comes around; we must, however, use lead and compression in some degree according to the engine we have in service. It is true that some small-ported slow-running engines will go without, but this kind would hardly be a fair comparison, and a well designed unit will run with less lead and compression than one poorly designed.

I can recall many cases where moving the eccentric slightly forward removed a fixed knock. I will agree with some fellow who writes that a knocking engine will run on less coal than some that do not, but who wants a knocking engine?

C. R. McGAHEY.

Lynchburg, Va.

Why the Pump Lost Its Water

A chief engineer wrote some time ago, asking what would cause the circulating pump of a surface condenser occasionally to lose its water, when the side was half out and half in. It was never known to lose it when the side was low or high. As no answer was ever published to this query, I submit the following solution:

To obtain a starting vacuum on this pump, a 1¼-inch pipe was run from the top of the shell to the jet condenser of another engine that was running. A valve, placed close to the circulating pump, was slightly opened until the suction pipe was full of water, when the valve was opened wide. It was important that this valve be shut after the pump was started, and before the jet condenser was shut down. This will at once give a clue to the apparent mystery. When the turbine started to lose its vacuum, the oiler made a rush for below-decks and quickly shut the valve. The first thing the engineer would also think of, when he got down there, was the valve, and he invariably found it shut, hence the mystery to him. That the side should be half out or half in was circumstantial only.

R. O. RICHARDS.

Framingham, Mass.

Alfortville Central Station, Near Paris

A Modern Plant in France, Using Horizontal Reciprocating Engines Direct Connected to Slow Speed, Revolving Field Alternators

BY FRANK C. PERKINS

One of the best examples of modern central stations in France using horizontal reciprocating engines direct-connected to slow-speed revolving field alternators is that at Alfortville, near Paris. This station is owned and operated by the Est-Lumiere company and is equipped with horizontal tandem-compound engines constructed at Ghent, Belgium, by the Société Anonyme des Ateliers Carels Frères, of Gand. The station has a capacity for six sections about Vincennes, Saint-Maur-les-Fosses and d'Ivry, the current being distributed as continuous current at 110 and 220 volts on the three-wire system in connection with storage-battery plants at the substations, and as 3000-volt primary, single-phase current with step-down transformers in the d'Ivry section. The current generated at the central station is three-phase alternating at 5250 volts pressure.

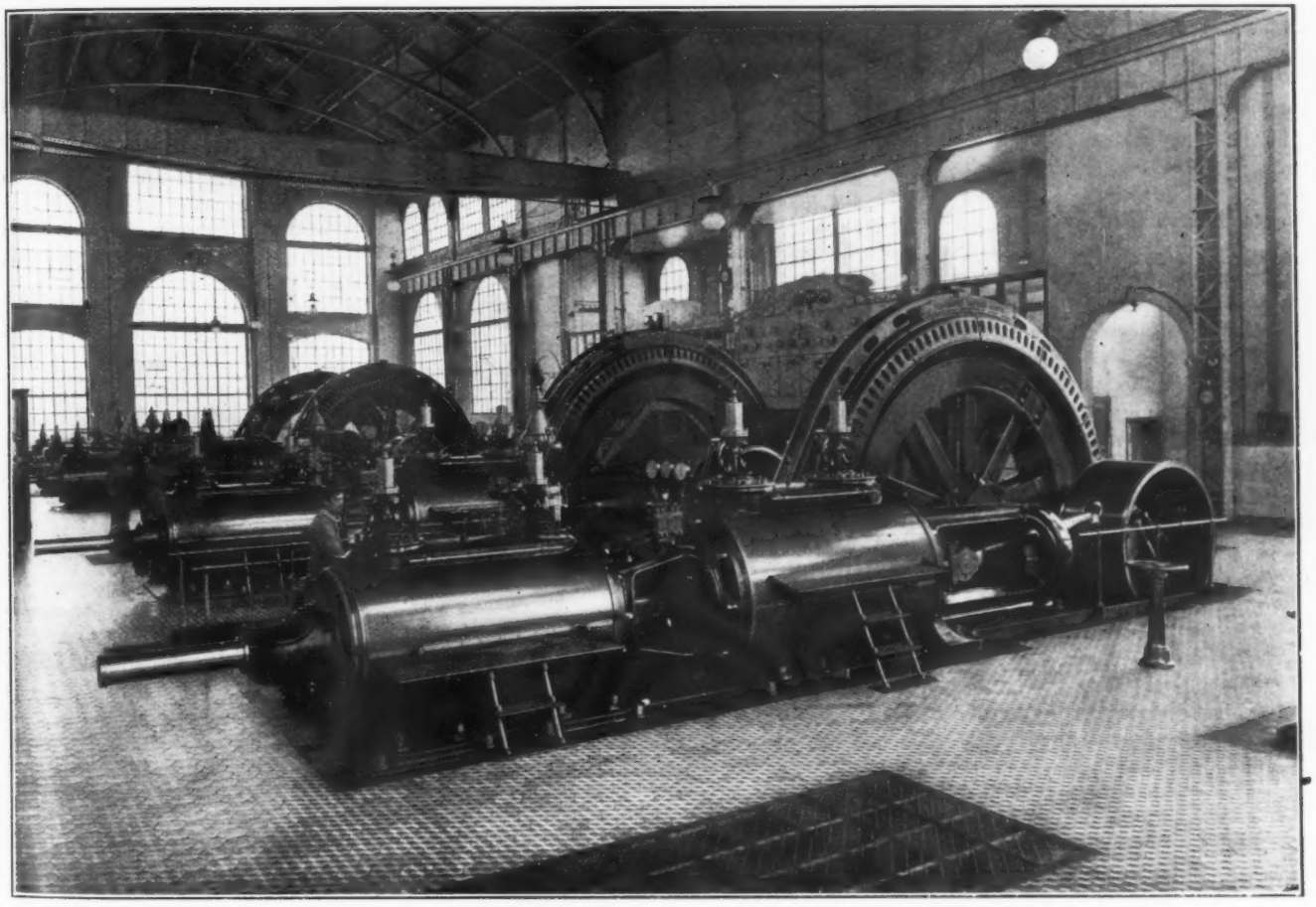


FIG. 1. INTERIOR VIEW OF ALFORTVILLE CENTRAL STATION

of these units, each of which is directly coupled to a three-phase alternator of the Alioth type constructed at Basle, Switzerland. Provision has also been made at this French central station located on the river Seine for an extension of the boiler and engine equipment for six more units of the same capacity.

The station, which is 73 feet wide by 187 feet long, was constructed for the Compagnie Est-Lumiere supplying those

The plans call for two chimneys 164 feet in hight, having an inside diameter at the top of 8.2 feet and an exterior diameter of 18 feet.

In the boiler room there are six batteries of boilers with a pair of boilers in each group, each supplying 6.86 pounds of steam per hour under a pressure of 26.4 pounds, with 100 degrees superheat. There are two Green economizers, each having 288 tubes 9 feet long, the auxiliary apparatus being driven by small electric motors of two horse-power each. In addition, there are two vertical pumps capable of delivering 766 cubic feet of water per hour, each operated by an electric motor of 12 horsepower capacity.

Tandem Engines Employing the Sulzer Valve Gear

In the engine and generator room the Sulzer tandem-compound engines are each capable of developing from 700 to 1000 horsepower, according to the cutoff in the high-pressure and low-pressure cylinders, with a speed of 100 revolutions per minute and a steam pressure of 22 pounds. Each engine has a stroke of 42 inches, the large cylinder having a diameter of 38 inches and the small cylinder a diameter of 24 inches.

An interesting feature of these engines is the Sulzer valve gear, which is shown

to advantage in Figs. 3 and 4, the former being a section through the low-pressure cylinder and the latter a section of the high-pressure cylinder. As apparent in Fig. 2, there are four valves per cylinder, two admission and two exhaust, arranged in pairs at the ends of the cylinder, with the admission above and the exhaust below. The valves are of the double-beat type employed in steam-engine practice, and are operated by trip levers, which in turn are actuated by an eccentric on a side shaft geared with equal gearing to the main shaft, so that it turns with the same number of revolutions per minute. To be more explicit, rod *A* in Fig. 4, in conjunction with arm *B*, raises the valve off its seat, and at the proper instant the governor, acting through lever *C*, releases the catch *D* and allows the valve to return to its seat. As the valve, when open, is in equilibrium, a spring on the valve is required to close it, and to prevent the valve from slamming down on its seat, a dash-pot is provided to control the action of the spring.

This description applies to the admission valves of the high-pressure cylinder, for, as shown in Fig. 3, the steam valves of the low-pressure cylinder have a fixed cutoff. The exhaust valves are actuated through a rod in connection with the

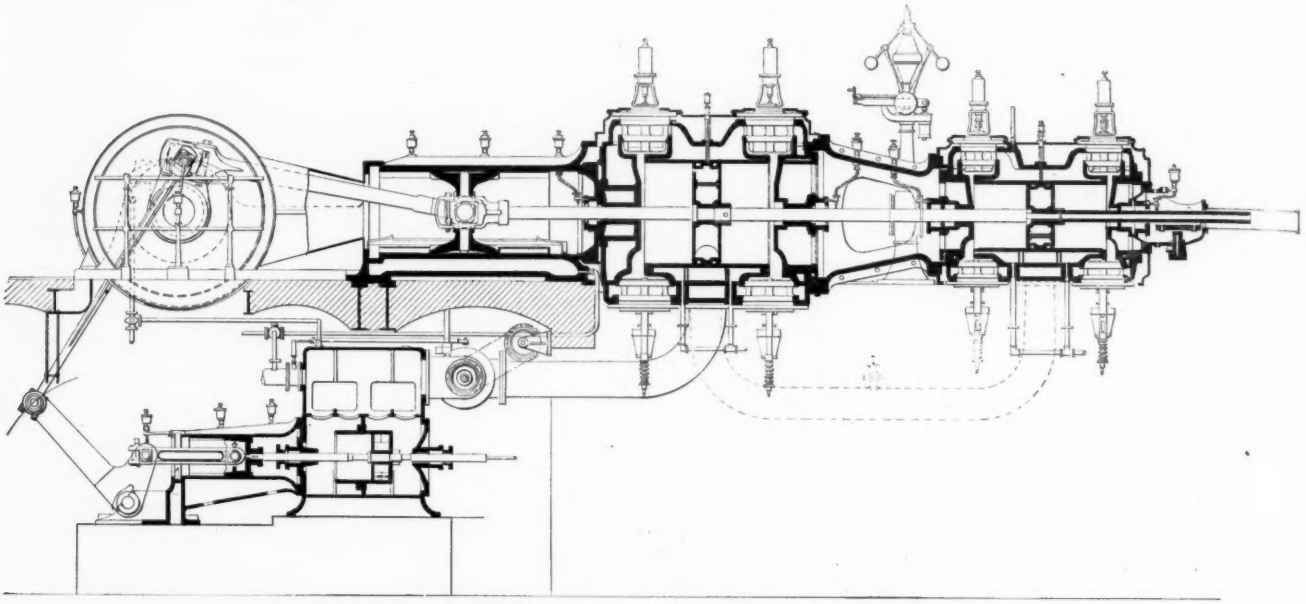


FIG. 2. SECTION THROUGH ONE OF THE 1000-HORSEPOWER TANDEM COMPOUND ENGINES

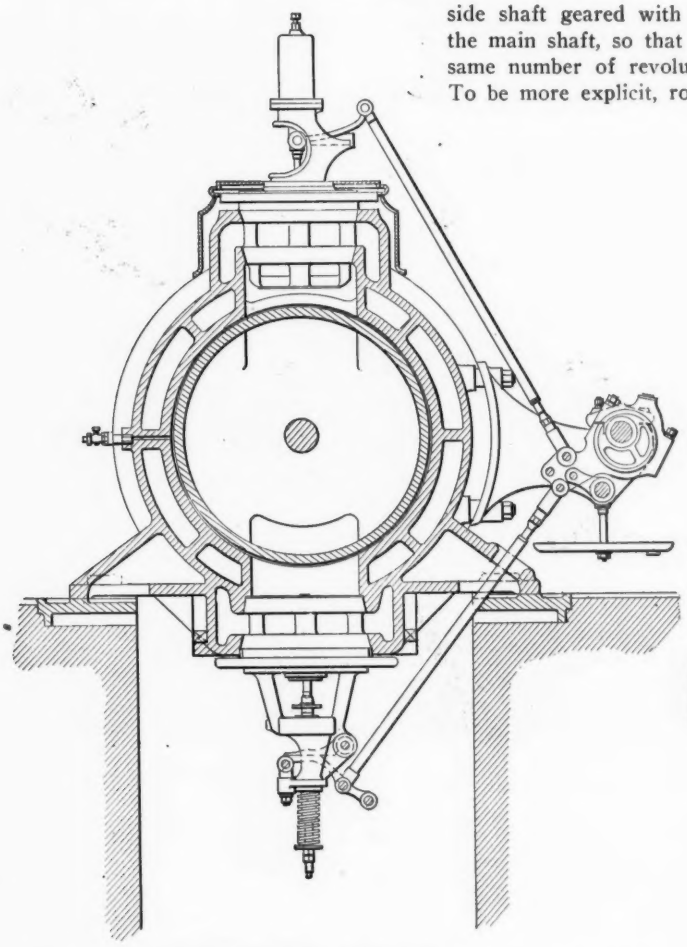


FIG. 3. TRANSVERSE SECTION THROUGH LOW-PRESSURE CYLINDER

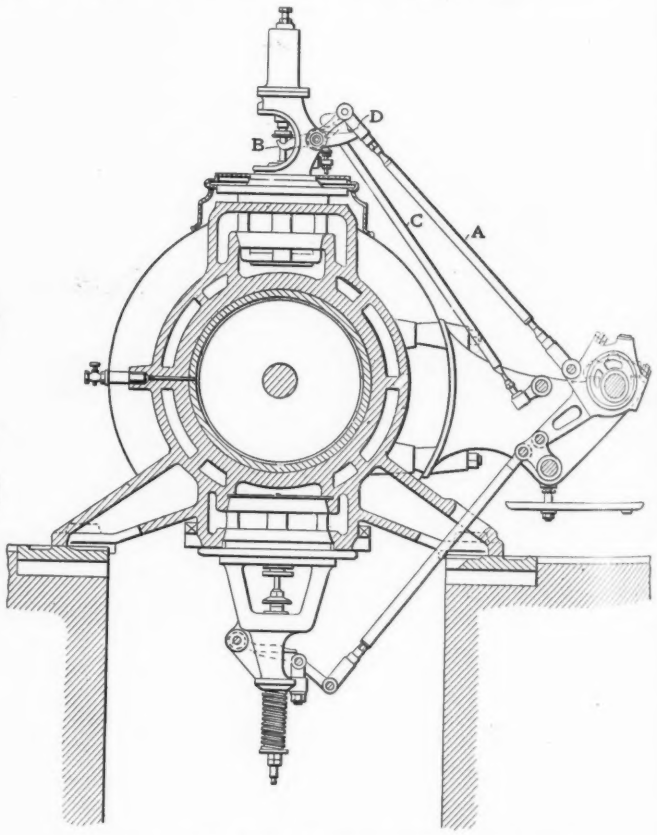


FIG. 4. VALVE GEAR OF HIGH-PRESSURE CYLINDER

same eccentric, their operation being plainly indicated in the illustrations. Other points of interest are the steam-jacketed cylinders, the condenser and the method of driving the air pump.

Electrical Apparatus

To each of the tandem-compound engines is directly coupled a three-phase alternator supplying current at 5250 volts and a frequency of 50 cycles per second. These machines were constructed by the Alioth Company and have a normal capacity of 720 kilovolt-amperes. The revolving field is 16 feet 9 inches in diameter and is provided with 60 field-magnet coils. It is constructed in two parts and weighs 38 tons. The stationary armature is constructed in four parts, and the total machine weighs 58 tons.

Continuous current of 125 volts is used for field excitation and is furnished by 75-kilowatt dynamos, which are directly coupled to three-phase asynchronous motors of 100 horsepower capacity. The motors are supplied with current of 5000 volts directly from the main alternator. A storage-battery plant has also been installed, and has a capacity of 400 ampere-hours on a 10-hour discharge rate. The switchboard is 46 feet long and occupies a space in the center of the engine and generator room. It is equipped with the usual rheostats, voltmeters, ammeters, wattmeters and the usual small-meter transformer mounted at the back of the board.

Steam Consumption Unusually Low

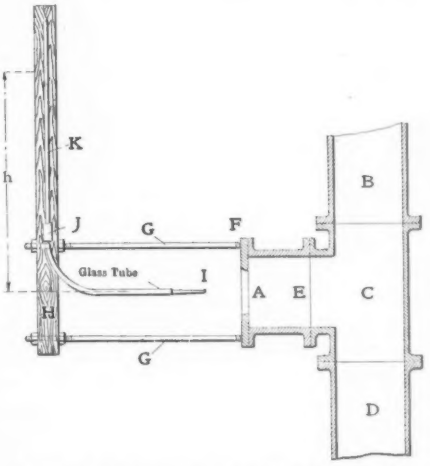
In this station it is of interest to note that high economy is obtained by the use of a thoroughly uptodate equipment for utilizing superheated steam. It is claimed that the consumption of superheated steam at 575 degrees Fahrenheit does not exceed 10 pounds per indicated horsepower-hour, while similar engines of Carels construction of the triple-expansion type have attained an economy of steam consumption of 8¾ pounds per indicated horsepower-hour. This shows the greatly increased economy due to superheated steam, as with a compound engine with saturated steam 13 pounds are required per indicated horsepower-hour.

A 4000-horsepower steam engine of the double horizontal type at the central electric-generating station at Brussels, has shown a consumption of 9.6 pounds of steam per indicated horsepower-hour, with loadings from half to full load. The engine has valves of the piston type, vertically arranged and operated from a lay shaft, and has 34½ and 60 by 60-inch cylinders. The ratio of areas of high-pressure to low-pressure cylinders is 1 to 2.97; the speed, 83 revolutions per minute; and the piston speed, 828 feet per minute.

Volume of Water Flowing from a Pipe

By F. Webster

It often happens that the stationary engineer is called upon to determine the quantity of water delivered by a pump, or to find out the quantity flowing from a pipe or flume so as to compute the power of the pump. There are quite a number of different methods of measuring the flow of water, and the one to select in any given case must depend upon the local circumstances and the equipment at hand. The meter method is the easiest one for the engineer to look after, but this method is evidently out of place where a very large volume is to be measured and a constant record is not required, as the cost of installing the meter would exceed all reason. Where it is possible to catch the flow in a tank or reservoir of known capacity,



PITOT TUBE METHOD OF MEASURING FLOW OF WATER

and by noting the time required to fill it, the rate of flow can be determined. Considerable care must be taken, however, in measuring the reservoir, especially when it is of large area, as a large error in the results may occur.

Where the engineer does not have any of the facilities mentioned, there is another method that is simple, inexpensive and accurate, and most any engineer should be able to get the device assembled and operate it. Technically it is known as the Pitot tube method, and by it the velocity of flow is determined; then the velocity in feet per second, multiplied by the area of the stream in square feet, gives the cubic feet of water per second. A diagram of the arrangement for measuring the flow of water by the Pitot tube method is shown in the accompanying illustration. To insure that the outlet of the pipe will always be entirely full, the outlet *A* should be arranged on the side of a vertical standpipe *B*, and the latter may be open at the top. The arrangement can be easily made by changing the usual elbow for a tee connection *C* fitted on top of the supply pipe *D*, placing the standpipe *B* on top of *C* and the horizontal delivery pipe *E* on the side opening in *C*. On the delivery end of the horizontal pipe, place a flange *F*, having an opening some two inches in diameter less than the pipe. The hole in this flange should be made with considerable accuracy, and for ease in making the subsequent calculation, the diameter should be preferably in even inches, that is, without any fractions. Thus, if the diameter of the horizontal pipe is 16 inches, make the hole in the flange 12 inches. If the diameter of the pipe is 12 inches, make the hole 8 inches. Besides having the hole accurately made and centered, the outer edge should be turned off, as shown, until only a very thin inner edge, about 1/16 inch or so, is in contact with the water. The flange should be prepared on a lathe by a machinist.

After the flange has been fitted, bolt two studs *G G* to the top and bottom, and about 2½ or 3 feet long. These can be screwed like stud-bolts into tapped holes in the flange. The outer ends of the studs should be threaded and have two nuts so as to clamp a vertical strip of wood *H*, a 4 x 4-inch about 6 or 8 feet long will do. This vertical piece is to support the Pitot tube, the end *I* of which must be located exactly the length of the radius of the opening in the flange from the inner edge of the flange; that is, if the flange is 12 inches in diameter, then the end of the tube must be 6 inches from the edge, and exactly central with the opening. The Pitot tube should be of small diameter, say 3/16-inch, straight and smooth inside, and conical on the outside so that the end will be very thin. The other end of the tube should form a curve, making a long easy bend, and it is then attached by means of a short piece of rubber tube *J* to a vertical glass tube *K*. The body of the tube could be made of brass so as to avoid rusting, and the conical point made of steel tube and swaged into the brass tube. The size of this glass tube is of no special importance, but a ⅝-inch tube will do, and the length required will depend upon the velocity of the water. A piece anywhere from 3 to 6 feet long will serve for most cases.

The nozzle of the Pitot tube should be rigidly supported and held in a horizontal position, and at exactly a radius length from the opening. The velocity of the flow of the water is determined by accurately measuring the vertical hight *h* of the water standing in the glass tube. The hight is the distance of the top surface of the water in the

glass tube above the center of the nozzle *I*. It should be understood that the flow of the water against the open end *I* of the tube will force the water into the glass tube, and hold it at some hight, depending upon the velocity through the flanged opening.

After measuring the hight in feet, use the following formula to get the velocity:

$$v = \sqrt{2gh},$$

where v stands for the velocity, h the hight in feet as measured, and g the acceleration due to gravity, or 32.16. The square root must be taken of the product of the hight by $2g$. Thus, suppose the measured hight to be 4 feet; then

$$v = \sqrt{2 \times 32.16 \times 4} = 16.04$$

feet per second.

The quantity of water in cubic feet per second is given by the formula

$$Q = 0.6\, A \sqrt{2gh},$$

where A is the area in square feet of the opening in the flange, and 0.6 is a constant found by experiment. This constant indicates that the size of the stream at a radius length from the opening is 0.6 of what it is at the opening. The fact that the stream is smaller in diameter at a short distance from the opening can be readily noticed upon observation. If the flange opening be assumed as one foot in diameter, then the area will be will be

$$\tfrac{1}{2} \times \tfrac{1}{2} \times 3.1416 = 0.7854$$

square feet. Then in the problem as assumed, the cubic feet flow per second will be

$$0.6 \times 0.7854 \times 16.04 = 7.55.$$

To get the quantity per minute, multiply by 60, and the quantity per hour will be 60 times that per minute.

If the lift of the pump is known, then the horse-power represented by the water delivered would be computed by the following formula:

$$H.P. = \frac{Q \times H \times 62.5}{33{,}000},$$

where Q is the cubic feet delivered per minute, H is the total hight of lift in feet, and 62.5 is the weight of a cubic foot of water.

In half the power plants of this country a 10 per cent. saving of fuel could be effected by employing trained, intelligent firemen.

Smoke prevention is not to be attained merely by installing improved apparatus. The apparatus must have intelligent and faithful attention.—*The Roller Mill.*

Horsepower of Streams

By N. A. Carle

The utilization of the water flowing in streams or over waterfalls is rapidly becoming a large factor in the development of power. The usual service for which the power is developed requires that it be converted into electrical power at the point of development and transmitted to the point of service. It is therefore desirable to know how much electrical horsepower can be obtained with a given amount of water flowing under a specified head.

The formula used to calculate the horsepower available for delivery is as follows:

$$H.P. = \frac{Q \times H \times 62.36}{550} \times e,$$

where

Q = Discharge of water in cubic feet per second,
H = Head in feet,
e = Efficiency of conversion.

The efficiency of conversion takes into account the losses of head due to entrance and exit and to friction in the conducting pipes, as well as the efficiencies of the water wheel and the electric generator. However, if the shaft horsepower of the water wheel is desired, this can be obtained by using an efficiency of conversion to correspond to the pipe-line and water-wheel losses up to this point.

The chart on page 673 is intended to show graphically the relation between the horsepower developed, the quantity of water flowing (up to 300 cubic feet per second) and the head under which the water flows (from) 10 to 120 feet, with an efficiency of conversion ranging from 40 to 100 per cent.

Examples

(1) What electrical horsepower can be delivered at the switchboard by a water-power plant which has a water supply of 200 cubic feet per second under a head of 75 feet, when the water-wheel and pipe-line losses are 25 per cent. and the generator and station losses are 20 per cent.?

The efficiency of the water wheel and pipe line is 75 per cent. and that of the electric generator is 80 per cent. The combined efficiency of conversion is their product, which is 60 per cent.

Starting at 200 cubic feet per second, read up to 75 feet head, on the accompanying chart, thence across to 60 per cent. efficiency of conversion and down to 1022, on the horsepower scale.

(2) What power will be available at the shaft of a water wheel operated by a flow of 120 cubic feet of water per second under a head of 50 feet, assuming that the pipe-line and water-wheel losses are 25 per cent.?

The efficiency of conversion is 75 per cent. Starting at 120 cubic feet per second, read up to 50 feet head, thence across to 75 per cent. efficiency of conversion and down to 511, which is the horsepower available at the wheel.

(3) What quantity of water per second, under 25 feet of head, is necessary to deliver 400 horsepower at the switchboard of a water-wheel plant which has a total efficiency of conversion of 50 per cent.?

Starting from 400 horsepower, read up to 50 per cent. efficiency of conversion, thence across to 25 feet head and thence down to approximately 280 cubic feet per second.

Allis-Chalmers Company's Annual Report

The annual report to the stockholders of the Allis-Chalmers Company for the year ending June 30, 1908, shows that the net total earnings were $615,814.24, after deducting cost of manufacturing and selling, taxes, insurance, maintenance and depreciation, interest, dividends on the preferred stock of the Bullock Electric Manufacturing Company, ordinary provision for doubtful accounts and general expenses, together with a special reserve of $60,000 set aside to meet possible contingencies due to financial conditions. The gross earnings amounted to $2,573,960.93.

The report also states that during the second quarter, and continuing for half of the fiscal year, owing to the contraction in general business throughout the country, the volume of sales averaged about one-half of normal. During the last half, however, there was a gradual and steady increase in orders booked.

A Note of Warning

A correspondent sends us the following account of an explosion in a gas producer used in street-railway work: Texas lignite is used for fuel and one Sunday night recently, while the engineer was endeavoring to get the clinker out of the producer, the gas exploded and, being overcome by the fumes, the engineer fell over the vent and was fatally burned, dying within twenty-four hours. It seems that lignite clinker has to be broken up with a poker and taken out with hooks through the opening in the top of the producer.

About 60 per cent. of the total area of Japan is occupied by carefully preserved forests. For many centuries the governing authorities of the empire have left nothing undone to conserve the forestry areas. At present the forests that are immediately under government supervision aggregate 58,000,000 acres.

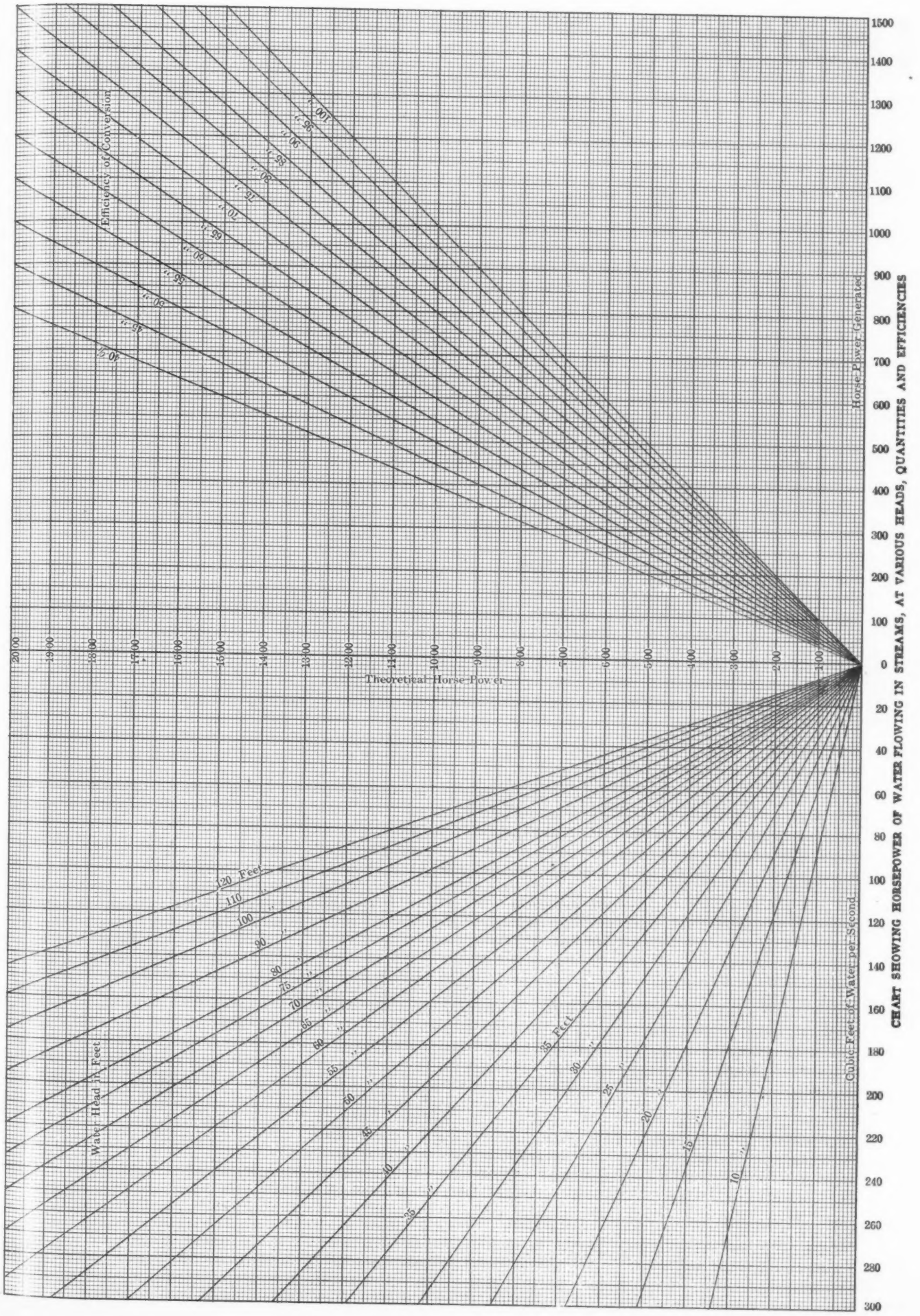


CHART SHOWING HORSEPOWER OF WATER FLOWING IN STREAMS, AT VARIOUS HEADS, QUANTITIES AND EFFICIENCIES
Efficiency of Conversion
Theoretical Horse Power
Horse Power Generated
Cubic Feet of Water per Second
Water Head in Feet
120 Feet
110 "
100 "
90 "
80 "
75 "
70 "
65 "
60 "
55 "
50 "
45 "
40 "
35 "
85 Feet
30 "
25 "
20 "
15 "
10 "

POWER AND THE ENGINEER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

Issued Weekly by the

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Our circulation for September, 1908, *was (weekly and monthly)* 194,000.

Oct. 6	38,500
Oct. 13	39,000
Oct. 20	39,000

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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A Record Breaking Power Plant

The Redondo plant of the Pacific Light and Power Company, described in the September 15 number, is remarkable in several respects. It will be remarked, first, that it is a reciprocating-engine plant, put in at a time when most of the large central-station work is running to turbines. When it was announced that C. C. Moore & Co. had been commissioned to build this station, and were making a comprehensive study of the comparative merits of turbines and reciprocating engines, their decision was attended with a great deal of interest. The only public announcement of that decision has been the adoption of the engine-driven type of generator for this station. A presentation of the consideration which led to that consideration would be extremely interesting reading not only for the partisans of the two types, but for the army of engineers and power users, who are watching the battle between the piston and the vane with a disinterested desire to know which is to be the type of the future.

Another remarkable point about the station is that it is claimed to have exceeded the economy of any central station of published record. The only figure of performance given is 252.84 kilowatt-hours per barrel of oil, with "a slight correction in favor of the contractors, because of excessive sulphur and moisture content." This is slightly under 25,000 B.t.u. in the fuel and about 1.32 pounds of oil per kilowatt-hour of net plant output.

It is unfortunate for purposes of comparison that this is an oil-fired station, as most of the stations in connection with which it will be considered are operated with coal. Upon the heat-unit basis a station would have to be turning out a kilowatt-hour on two pounds of coal containing 12,500 B.t.u., or two and a half pounds of 10,000-B.t.u. coal., and this must cover all the coal used for all purposes, including banking, which latter expense has no counterpart in a station where oil is used.

The guarantee was based upon the fuel consumption and nothing is said of the labor account, which is one of the points upon which the turbine is said to be ahead. Even were the labor costs available, they would not be comparable with those of a coal-burning station.

Another particular in which the station is remarkable is the handsome bonus of $363,310 which it earned for its designers—the largest bonus ever paid on a steam-power-plant guarantee, as far as we know. By the terms of the guarantee the purchasers were bound to get a station of excellent efficiency, or a forfeiture which would make good any shortcoming; while the contractors were given the opportunity to earn, by exceptional accomplishment, a sum which, although considerable, will be wiped out in two or three years by the excess efficiency of which it is the price.

We congratulate the Pacific Light and Power Company upon the possession of so efficient a station, and C. C. Moore & Co. upon their achievement.

Operating Engineers and Mathematics

As our regular readers know, we have frequently urged the advantage to operating engineers of a knowledge of elementary mathematics—algebra and trigonometry—and we thought we had done it in a tone corresponding to the kindly feeling which we have for all conscientious engineers. Therefore, we were surprised and disappointed recently to receive from a reader of sterling worth and practical ability a letter in which he said, incidentally, that we had scolded engineers for not learning mathematics. Now, nothing has been farther from our intention than to scold anyone, except shirkers and fakirs, for whom we feel the utmost contempt and antipathy. To the hard-working, ambitious engineer we are friendly in the extreme, and we are always glad to further his interests; for this reason we have tried to point out the folly of refusing to learn to use simple formulas. Aside from the fact that it is impracticable to express some relations in any other way than by a formula, there are the advantages that even those numerical relations which can be explained in words are much more clearly expressed by formulas and more readily grasped, and that a man accustomed to the use of formulas has, almost always, quicker wits and keener perception than one who is not.

The superiority of formulas over rules is easily demonstrated. The simple gas formula $P\ V \div K = T$ can be readily expressed in words: "The absolute pressure per square foot multiplied by the volume in cubic feet and divided by a constant equals the absolute temperature." But what a "mess" of words that is, and how little it means until you put it down in the shape of a formula. Then one sees at a glance not only the rule but its results, such as the fact that with constant pressure, an increase in volume means an increase in temperature, or with constant volume, any change in pressure means a corresponding change in temperature. This is one of the simplest of the many examples of the great advantages of formulas over words; engineering of all grades abounds with them, and the engineer who fails to recognize that truth and act on it merely stands in his own light. However, we feel only sympathy for him—not any desire to scold or berate him.

Operating a Gas Producer

While it is rash to the point of culpability to assert that "anybody" can attend to a gas producer, it is undeniably true that much less skill is requisite to fire a producer properly than to fire a steam boiler properly, the term "properly" meaning with satisfaction to the engine room, economy in the use of fuel and minimum wear and tear of the apparatus. "Anybody" can shovel coal into a furnace, but not everybody can keep up steam with the minimum consumption of coal, which involves keeping the fire at the proper thickness (or thinness, rather), the water level at the proper point and attention to the many minor details which an expert fireman handles quietly and easily and the other kind forgets, ignores, or doesn't even know. On the other hand, the feeding of fuel to a gas producer requires no more intelligence than does the dumping of a hod of coal on a grate fire, but maintaining the more active part of the fuel bed in good condition is quite another matter. However, intelligent poking and the regulation of the water supply are really all there is to the correct operation of a suction producer, and there is no comparison between these limited duties and the manifold attentions required by a boiler and its appurtenances. Pressure producers require somewhat more attention than the suction type, especially if the steam is supplied by a separate boiler, and approach more nearly the steam plant in their demands on attendants. But we are hoping some day to see the pressure type superseded by the induced-draft type, for power-plant work, or, at least, the separate-boiler nuisance eliminated entirely.

Denatured Alcohol

When Congress removed the internal-revenue tax from denatured alcohol, it was predicted that it would soon become apparent that by this one act Congress had done much for the people as a whole, and that the beneficial effects would begin to be felt at once. Notwithstanding, however, that denatured alcohol has been unburdened by an internal-revenue tax for nearly two years, there does not seem to have been any particular increase in its consumption commercially; and the demand for internal-combustion engines using denatured alcohol for fuel has not stimulated their manufacture to any noticeable extent, although columns of editorial space have been devoted to this feature of the case.

When Congress removed the tax on denatured alcohol, the country was in an unusually prosperous condition. Business was good, and there were plenty of optimists who would not hesitate to declare that almost anything would be a success, which may account for the enthusiasm displayed in welcoming this new fuel; while the alarmists, who bemoaned the prediction that within a few years the coal supply would become exhausted, found consolation in the promised advent of this substitute that could be obtained from potatoes, corn, sawdust and old boots. But where is it? Is it lost, strayed or stolen?

If the claims for denatured alcohol can be sustained, there should be nothing to prevent its free use for power purposes in internal-combustion engines. It is said that a gallon used in this type of engine will do the same amount of work as a like amount of gasolene, but the cost is slightly greater. The retarding influence to the more extensive use of alcohol for power purposes, therefore, seems to be the failure thus far to produce it at a less cost than its rival, gasolene. The argument that the lack of suitable engines is at all responsible for the non-use of alcohol is not tenable; when there is a demand for alcohol engines, that demand will be met.

Old Age Pensions

One interesting feature of the National Association of Stationary Engineers' convention at Denver was the plea of Mrs. Nella C. Moore, national president of the Ladies' Auxiliary, to the national body to take some steps toward making provision for superannuated and indigent members of the association. In his independence of spirit and tendency toward individualism, the American has been slower than the European to take up the matter of old-age pensions and insurance against unemployment, and the engineer, whose work is such that in most cases, and particularly in times of emergency, he must be "sufficient unto himself," will be one of the last to think of coöperative action with his fellows in providing for himself and family against the dark days of old age or helplessness. As a member of other fraternal organizations, he is sometimes forced to take a passive part in the sick and death benefits, but the idea of an organization composed entirely of engineers and members of his own national educational association has not appealed to him.

Unless one comprehends the influence of an engineer's work upon his mental attitude, this state of mind is not readily understood. It speaks well for the sound judgment of the delegates that action was taken on Mrs. Moore's suggestion and a committee, consisting of delegates all from one locality, was appointed to submit to the next convention a working program of a system of old-age pensions in accord with the ideas advanced by Mrs. Moore.

The association has had in operation for the past twenty years a life and accident department conducted on the assessment plan, membership of which is optional to the member of the national body, which pays a $500 benefit in case of death, total disability and certain specified accidents; but this department makes no provision for superannuation or unemployment, nor is participation in it obligatory. It would seem that at least until the Government recognizes the advisability of enacting laws, similar to those in vogue in other countries, for providing for the old and infirm, and the aged have other places of refuge than the poorhouse, Mrs. Moore's idea should grow with the National Association of Stationary Engineers, and protection, as well as education, become a salient feature of this organization. It is sincerely to be hoped that the incident will not end with a report of the committee at the next convention.

Honor to Whom Honor is Due

In the libraries and textbook schedules of colleges and universities you will find works on thermodynamics by authors varying in rank from mediocrity to Rankine—but none by Clausius, as a rule. In most of those works you will find entropy discussed with more or less intelligence (usually less) and its origin ascribed to Rankine, or Carnot, or Thomson, or someone else—but not to Clausius.

Now it is a matter of cold history that Clausius not only originated the conception of entropy, but gave it its name; that Rankine and others recognized the immense importance of the idea and analyzed its application exhaustively, but it originated in Clausius' brain, and it has never been more comprehensively nor clearly presented than in his own work. Moreover, a collection of books on thermodynamics without Clausius is almost like Hamlet with the Dane omitted.

Acknowledge Receipt of Catalogs

Engineers are more deeply indebted to the manufacturers for one source of knowledge than they seem to realize. There is no portion of the engineer's library that is more often referred to than the trade catalog and the recipient should not allow the donor to exceed him in courtesy. In short, when a catalog is received by an engineer, its receipt should be acknowledged, and if its advent is welcome mention should be made of the fact.

When it is remembered that there is as much power in the steam from atmospheric pressure down to 27½ inches as there is from 150 pounds down to atmospheric pressure, it is easily seen that the power of a noncondensing plant can be doubled by the addition of an exhaust-steam turbine and condenser, and in cases where there is not a supply of cooling water, improvements in cooling towers have enabled them to be put up both cheaply and well.—Gerald Stoney, before the British Association.

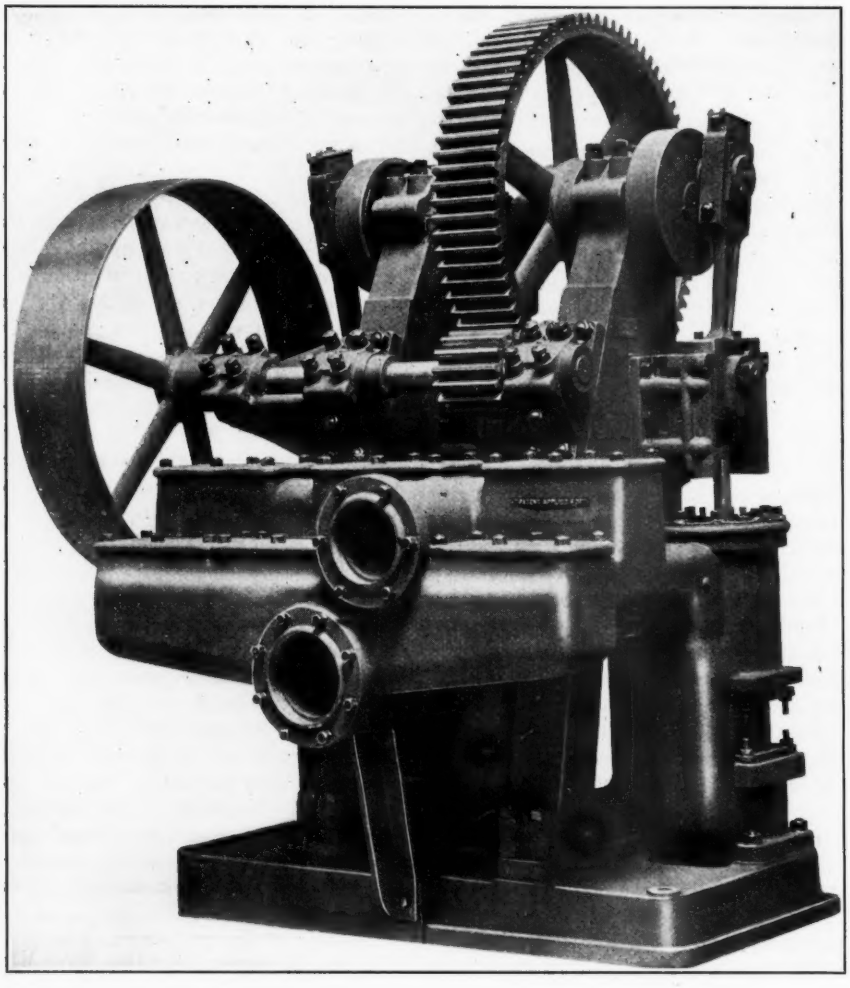
Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

Vertical Triplex Double Acting Outside Packed Power Pump

The outside-packed plunger pump has been the recognized standard for many years for handling water containing grit or dirt of any character. It is at the present day rapidly gaining favor as a general service type, on account of the ease with which any leakage is detected and remedied.



VERTICAL TRIPLEX DOUBLE-ACTING OUTSIDE-PACKED POWER PUMP

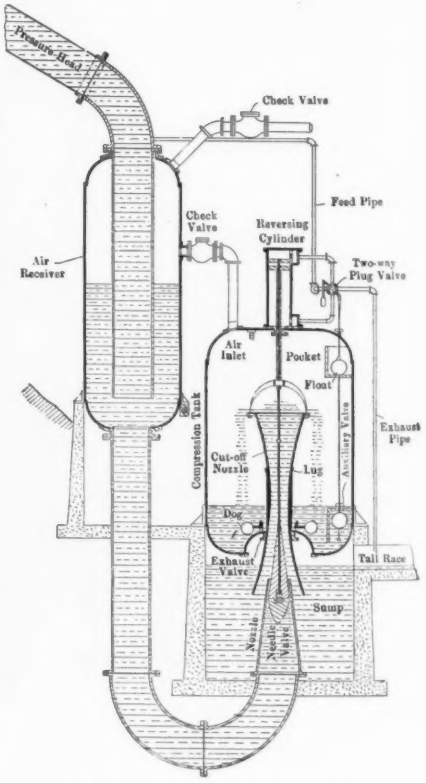
The pump shown in the illustration has been designed to unite the advantages of the double-acting type to those of the outside-packed plunger construction. The machine gives a large capacity for a minimum floor space. The valve chest is of special design, allowing all of the valves to be placed on one side of the pump, thus leaving the other side perfectly clear and providing easy access to the plunger glands. Each set of valves has its individual cover so located as to provide for the convenient inspection of the valves.

The power end is of the Deane standard type having a single main gear located between the crank-shaft bearings. The crossheads have adjustable shoes running in bored guides, as shown on the right-hand crosshead.

The Deane Steam Pump Company, of Holyoke, Mass., has made application for a patent covering this design. They are prepared to furnish pumps of this type in capacities from 100 to 1000 gallons per minute.

McFarlane Hydraulic Air Compressor

An hydraulic air compressor of the direct-acting, pulsating type, was recently designed by George C. McFarlane, 312 Bearinger building, Saginaw, Mich., to effect an economy of water and energy by adapting the pressure of the water to that of the air to be compressed. To compress air to 85 pounds pressure requires a 200-foot gravity head of water. If this head were turned directly into a tank full of air, it would compress the air to 85 pounds pressure and force it out of the tank at that pressure; however, an enormous loss of energy would take place in the initial stages of compression. To compress the air without loss of energy requires that the water pressure entering the tank should be only slightly greater than the pressure of the air at any given stage, i.e., starting at a couple of pounds pressure, gradually increasing to 16 pounds when the tank is half full, 46 pounds when the tank is three-quarters full, increasing thence to the final pressure, 85 pounds



M'FARLANE AIR COMPRESSOR

when the tank is 85 per cent. full, then using the full water pressure to fill the remaining 15 per cent. of the tank, thereby expelling the compressed air into the receiver. In the McFarlane system this pressure regulation is intended to be accomplished by intermingling various percentages of dead water with the inrushing jet of live water.

A nozzle, or monitor, connected with a head of water, produced either by gravity or a turbine pump, is mounted under an air tank. By an arrangement of a shifting cutoff nozzle and a needle valve, it is expected that the stream issuing from the monitor will sluice in enough dead water from the sump to reduce the velocity head of the stream entering the tank to the air pressure it must overcome: In the initial stages a small opening of the nozzle sluices in a big stream of dead water from the sump, in the final stage the needle valve gives a full opening of the nozzle, while the cutoff valve shuts off all or nearly all the dead water.

The accompanying illustration shows the operation of the system; the pipe head passes down through and nearly to the bottom of the air receiver; from the receiver the water is conducted down a pipe, through a return bend up into the nozzle, whence it is periodically admitted into the compression chamber. The nozzle is opened and closed by a needle valve, and a vertically moving cutoff nozzle regulates the amount of dead water admitted with the live head. The needle valve and the cutoff are moved up and down by separate pistons operating in one reversing cylinder, their movements being controlled by floats, which operate a two-way-plug controlling valve, to admit water above or below these pistons. An exhaust valve for quickly emptying the tank is raised by the upward movement of the cutoff nozzle, the receding water level releases the float-operated dogs and permits the exhaust valve to drop back into place when the tank is nearly empty. The floats which move the controlling valve work in pockets and give a quick reverse to the valve.

Starting with a tank full of water, the bottom float being down, the controlling valve directs the feed water into the upper port of the reversing cylinder; this shoves both pistons down, lowering the needle valve and cutoff nozzle. As the water flows into the tank compressing the air, the rising water level raises an auxiliary valve against the drain holes in the upper pocket, and no water can enter the upper pocket until the water level reaches the top of the pocket, when it overflows and quickly throws up the float, reversing the controlling valve, which now directs the feed water into the lower port of the reversing cylinder. Now since the lower piston head rests tightly against the lower cylinder head, the force of the water is expended in raising the upper piston, which closes the needle valve; near the end of this up-stroke, a dog nut on the needle-valve stem engages the bottom of the hollow rod of the lower piston, raising it enough to clear the lower cylinder port. The lower piston now catches the full water pressure, and the cutoff nozzle and the exhaust valve are raised. As the tank empties, the receding water level releases the exhaust-valve dogs, permitting the valve to close; the lower float also drops, reversing the controlling valve, and beginning a new cycle.

Each cycle requires ordinarily about 15 or 20 seconds, and a nearly constant air pressure is maintained in the pipe line throughout the cycle by the rising and falling of the water level in the air receiver. While the special field of this system is direct compression from natural heads of 200 feet and more, it can also be used with an artificial head produced by a multi-stage turbine pump.

The "Universal" Stoker

The "Universal" stoker is the name of the new automatic smokeless stoker manufactured by the Oscar Barnett Foundry Company, Newark, N. J. It is of the traveling chain-grate type with several novel features. The grate bars, which are continuous across the furnace, are of an interlocking fishbone type, giving a large percentage of air space. They are fastened at each end to a chain of ordinary round-iron links of equal pitch. One end of the grate bar is fastened into a vertical link, and the other to a horizontal one, which gives each bar, as the chain passes over the supporting rollers, a slight oscillating motion, which, combined with the undulations of the grate as it travels, loosens the fire bed just enough to allow the passage of air through the body of incandescent fuel to prevent the formation of large clinkers.

At the rear of the grate the ashes and cinders are carried on to a cinder-and-ash catching plate designed to offer a slight resistance to the movement of the fire bed, force the fuel into closer contact and prevent the formation of holes. The "dead plate" is not one continuous plate, but is

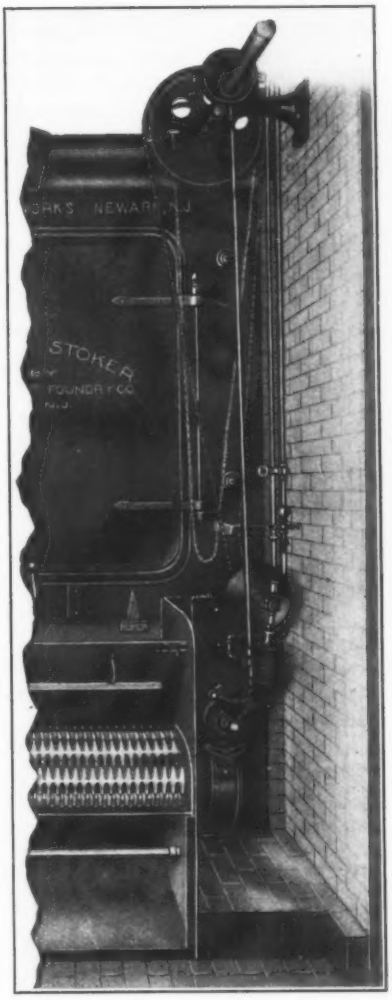


FIG. 1. "UNIVERSAL" STOKER AS APPLIED TO A HORIZONTAL TUBULAR BOILER

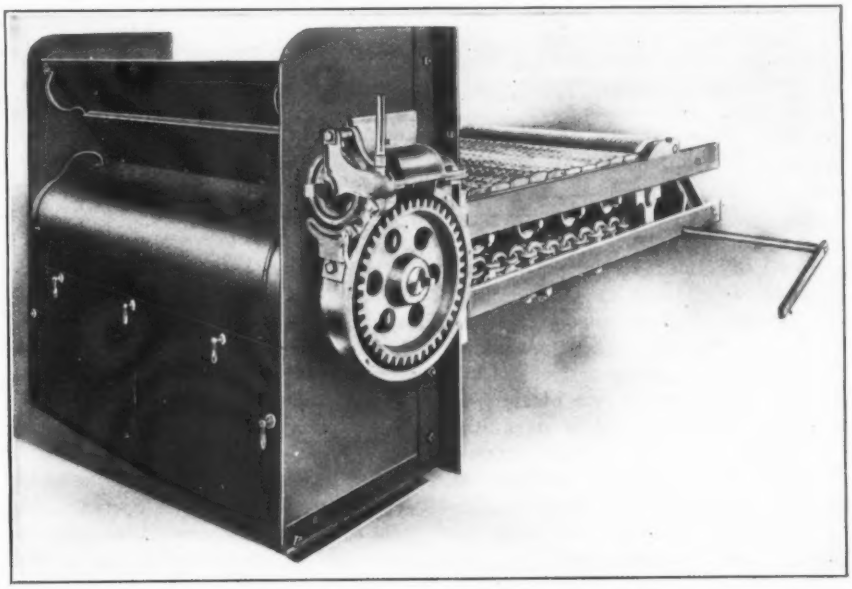


FIG. 2. SHOWING ADAPTATION FOR FORCED DRAFT

made of sections of about 1 inch in width, oscillating on a bar directly in front of the dumping plate. This oscillation is intended to allow each section to rest upon the grate at all times and prevent a leakage of cold air into the furnace. If for any reason it becomes necessary to draw the fire, it is quickly done by removing a plate on the front of the hopper and drawing the fire out over the front of the grate.

The frame is made of structural material throughout, firmly supported within the furnace chamber. The transmission medium is a worm and gear inclosed in a casing forming part of one of the propelling-shaft bearings and is filled with oil which does not have to be renewed often. A small ratchet wheel mounted upon the worm shaft is inclosed by ball-and-socket joint brackets, as shown in the drawing, and is connected to an eccentric propelled by any suitable motive power, but preferably by a practical oscillating engine, such as is shown at the right in Fig. 1. At the rear of the stoker is mounted the flexible bridge upon which the ashes and refuse are transferred to the dump plate, which is of solid and blank construction and when closed is practically air-tight. It is operated from without the furnace. Fuel goes from the hopper through the fuel ports from 5 to 8 inches thick, as is desired. In its travel to the rear of the stoker the fuel is kept loose and it is to a large extent prevented from coking into a solid mass by the irregular motion of the grate surface and chain while traveling over the supporting rollers and between them.

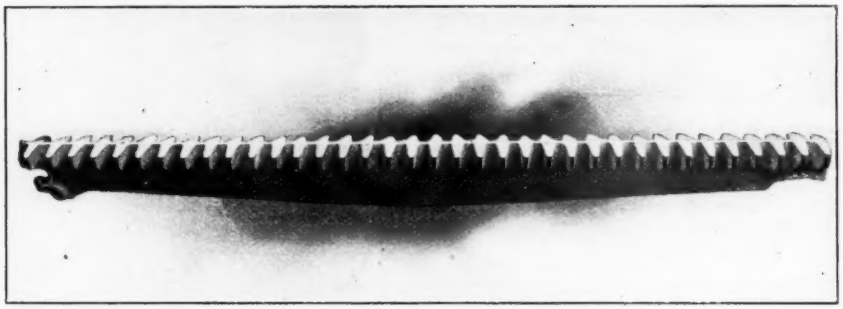


FIG. 4. REGULAR FORM OF GRATE BAR

With a depth of fire of 7 inches and a chimney draft of 1 3/10 inches it is said to be possible to burn 50 pounds of bituminous coal per square foot of grate surface per hour with freedom from smoke. Fig. 1 shows the stoker as applied to a horizontal tubular boiler with natural draft. Fig. 2 shows the method of adaptation for forced draft by means of removable air-tight plates over the front openings. Fig. 3 shows a sectional view of the apparatus as applied to the boiler of the Oil Well Supply Company. Fig. 4 shows the regular form of grate bar which may be replaced at any time during operation, if necessary, without stopping the operation of the stoker.

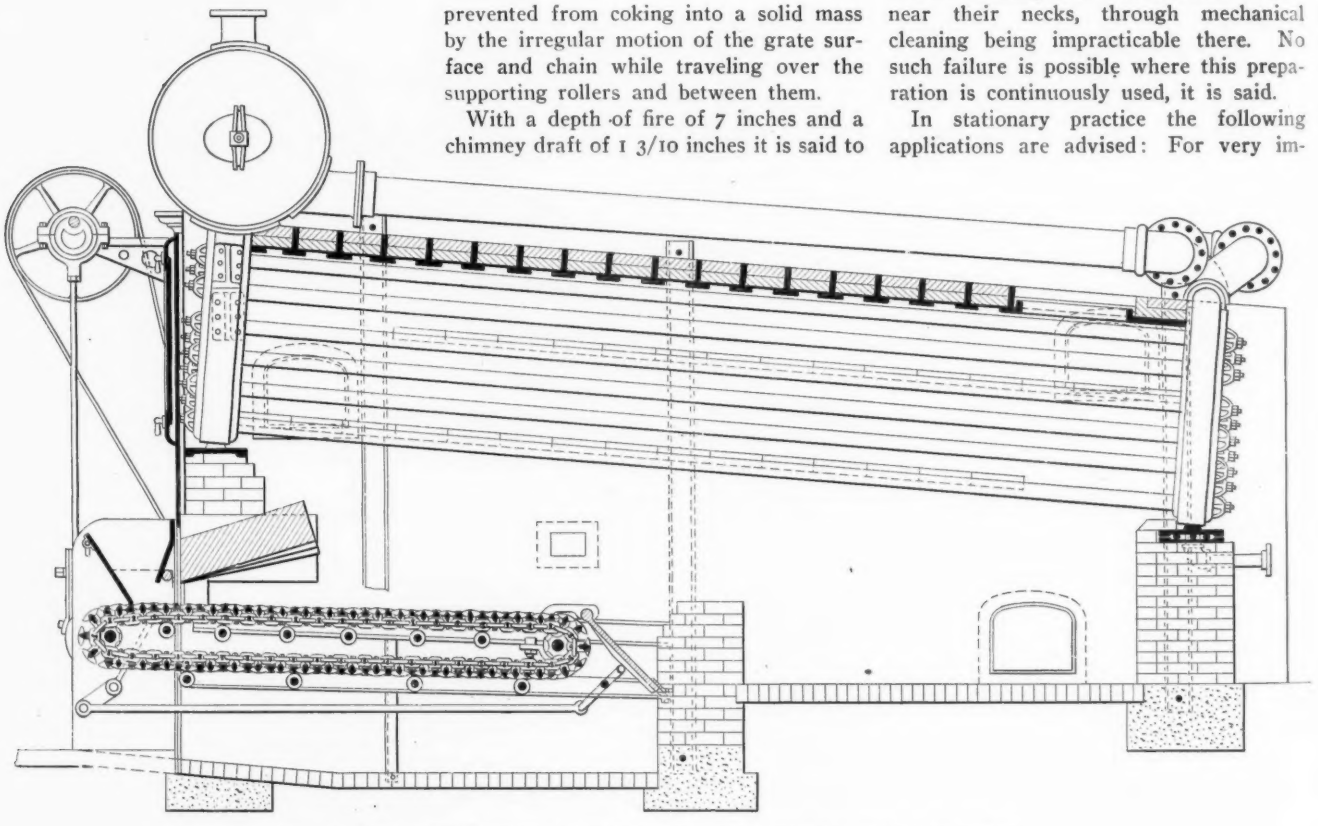


FIG. 3. "UNIVERSAL" STOKER APPLIED TO OIL WELL SUPPLY COMPANY BOILER

Atlas Boiler Preservative

The constituents of "Atlas" preservative are mineral, and its action is said to be entirely different from all other methods of boiler treatment. It is claimed not to be merely a scale remover, but also to arrest and neutralize corrosion and grease in marine, stationary and locomotive boilers where water-softening is impracticable.

By its use it is claimed that rust is disintegrated to its base, and its further action is neutralized.

Scale is said to be gradually disintegrated from all parts of a boiler, and precipitated in granular form to the bottom, and as this preservative acts quicker on oxidation and corrosion than on scale, where these exist at the base of scale the latter is frequently removed intact.

Tubes usually fail from corrosive action near their necks, through mechanical cleaning being impracticable there. No such failure is possible where this preparation is continuously used, it is said.

In stationary practice the following applications are advised: For very impure water put in two quarts for each 1000 gallons water capacity on filling up, and inject one pint for each 1000 gallons water capacity every three days. To facilitate the removal of old scale after blowing down, make two injections of two quarts each for every 1000 gallons water capacity on successive days, the last four days before stopping for cleaning. It is manufactured by the Atlas Preservative Company of America, 30 Broad street, New York City.

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Starting a Corliss Engine

A Corliss engine that cuts off at ¼ stroke is stopped with the piston at the middle point of its travel and, consequently with both steam valves closed. How would you start it?

J. B.

Work the valves with the hand bar in the wristplate.

Pop Safety Valves

What causes a pop safety valve, set to blow at a certain pressure, to let the pressure below the blowing point before it closes?

F. A. W.

Pop safety valves are so designed that when they rise off the seat increased area is exposed to the action of the steam and the valve can only close against a pressure lower than that which opened it.

Setting Slide Valves

Can a slide valve be set to cut off at quarter stroke without the use of a riding cutoff valve?

J. F.

It is not practicable with a slide valve to cut off the steam supply to the cylinder as early as you mention, or much earlier than three-fourths stroke. With the riding cutoff, the main valve is designed and set to take steam at very nearly full stroke.

Increasing Power

How can the power of a slide-valve engine be increased when it is taking steam full stroke, without increasing either the speed, or boiler pressure and without adding a condenser?

W. F.

If the engine takes steam full stroke its speed could only be increased by a higher steam pressure or lower back pressure. As these are forbidden, your only remedy is to use a larger steam cylinder.

Recipe for Metal Polish

Please give me a simple recipe for making a liquid polish for brass and iron work.

W. G.

Take one ounce of oxalic acid, dissolve it in one pint of soft water, apply with a cloth or rag and rub dry immediately to prevent corrosion or spotting by the acid. Another good polish is made by taking one ounce tripoli powder and one pint of benzine. Shake thoroughly before using; apply with a cloth or rag and rub immediately.

Burning Slack Coal

In burning slack coal, is it good practice to use exhaust steam in the stack to create a draft? The stack is made of No. 14 steel plates.

L. B. S.

It is not considered good practice to use exhaust steam in a steel or iron stack, particularly if there is any sulphur in the coal burned, as the fumes will unite with the water in the steam, forming sulphurous acid, which soon oxidizes, becomes sulphuric acid and attacks the iron or steel, rapidly destroying it.

Steam Boiler Testing

Is it considered good practice to test a steam boiler which is connected with others by having a steam header common to all, the feed water for the boiler to be tested to enter independently; in other words, is it necessary to *entirely* separate the boiler from others while testing?

W. A. H.

The boiler should be "cut out" entirely, both as to steam and water connections.

Effect of Clearance on Mean Effective Pressure

What effect has the clearance on the mean effective pressure?

J. B.

Clearance increases the mean effective pressure with a given cutoff in the relation:

$$Pm = \frac{(1 + log\ R)\ (1 + c)}{R} - c,$$

R being the actual ratio of expansion, i.e., the stroke plus the clearance divided by the fraction of the stroke completed at cutoff plus the clearance, and c the clearance expressed as a fraction of the stroke. It would take an article with diagrams to explain this intelligibly.

Returning Condensation from Heating Coils

Can the condensation from heating coils or radiators be returned to the boiler by gravity?

P. C. G.

Yes. This is in accord with ordinary steam-heating practice, where the water condensed in the coils is allowed to flow back to the boiler. The return pipe may be connected with the boiler at any convenient point, preferably, however, below the water line; or it may be omitted entirely and the water allowed to return through the steam-supply pipe, as is practiced in some cases. If the radiators are below the level of the water line in the boiler, a pump or some form of return trap will be necessary.

Engineers' License Laws

Will you please tell me in what parts of the United States engineers' license laws are in force?

C. F. A.

As far as known, Massachusetts, Minnesota, Montana and Ohio are the only States having State license laws. Many other States have passed acts of legislation permitting cities to pass license ordinances, under which the following cities have some form of engineers' license: New Haven, Conn.; Buffalo, Rochester, Niagara Falls, Poughkeepsie and Yonkers, N. Y.; Allegheny, Philadelphia, Pittsburg and Scranton, Penn.; Detroit and Saginaw, Mich.; Los Angeles and San Francisco, Cal.; Seattle and Tacoma, Wash.; Denver, Colo.; Sioux City, Ia.; Chicago and Peoria, Ill.; St. Louis, Mo.; Louisville, Ky.; Memphis, Tenn.; New Orleans, La.; Baltimore, Md.; Jersey City, N. J., and Atlanta, Ga.

Draft Gages

I have seen several illustrations of draft gages and wish to know what they really tell. Does the difference in hight of the water in the right- and left-hand tubes show the velocity of the gases up the chimney, or the amount of vacuum at the point where the gage is attached?

A. B. H.

The difference in level in the legs of a draft gage represents in inches of water the difference in pressure between the inside and the outside of the chimney, due to the temperature of the gases and the hight of the chimney. The glass gage in a sense does measure vacuum, but its reading should not be compared to those of the ordinary vacuum gage without understanding that the latter reads in inches of mercury, which is about 14 times as heavy as water, and 1 inch measured on the draft gage would correspond to only 7/100 of an inch on the vacuum gage. The water gage, being more delicate, is used where very slight differences in pressure are to be measured. The draft gage does not indicate the velocity of the gases up the chimney.

Obituary

Harry J. Ott, superintendent of the Illinois Engineering Company, died in Denver, Colo., on September 25, of typhoid pneumonia. He was a member of the Illinois chapter of the American Society of Heating and Ventilating Engineers and of the Western Society of Engineers. He had been with the Illinois Engineering Company for more than six years and was a frequent contributor to technical papers on heating and engineering subjects.

Personal

H. Hamkens, for the past six years in charge of the Corliss- and blowing-engine department of the Mesta Machine Company, of Pittsburg, has established a consulting-engineering office for himself at Princeton, N. J.

Remedies for Gas Engine Troubles

By R. O. Klepinger

I was called upon to find the trouble with a gas engine that would run finely until it became heated, and when it was hot enough to run with the most economical amount of fuel the engine would die, almost on the instant. It would be impossible to start or get an explosion out of it until it became cool, and then it would start off as nicely as any.

While it stumped us for a while, we found that the stationary insulated electrode of the make-and-break sparker short-circuited when it became hot, by expanding enough to touch the movable electrode. Some people made pointed remarks about it before it was fixed, but I called it plain cussing.

Are you troubled with water in the cylinder, after letting it cool from a long run? If so, place the exhaust cam so the exhaust will be open and then prop the inlet valve open, and you will not be bothered with wet cylinders.

Remember, when dismantling a gas engine for repairs, to mark the teeth on the two-to-one gears, so you will not make a mistake when erecting. This might be an old saw to some, but there are a few men running engines who have never dismantled them and never take the pains to mark the gears, and when erecting you will find that you have saved a lot of work by having the valves work as they should.

If you strip bolts and taps in engineering work, just remember that graphite rubbed on the threads will save you the annoyance again, and graphite in gas-engine packing work is almost a necessity, as packing on the hottest parts of the engine when covered with graphite will come away from the metal perfect.

Does your engine back-fire a great deal, and you find it very hard to stop? Look for pockets in the cylinder or valve chambers, or holes bored and threaded for the indicator, with the tap not reaching clear through. A very poor mixture will also cause back-firing. Because of slow burning, there will be a flame in the cylinder to ignite the incoming charge.

I am an enthusiastic believer in the gas engine, and have never been up against an engine that I could not get satisfactory service out of, but it is foolish to think that any person not acquainted with them could take a plant and always give good service, as some of the catalogs say.

Prisoner-Inventor is Offered Fortune

"If you can prove to me that your invention will do all you claim for it, I will here and now sign an agreement to purchase $40,000 worth of stock in your company."

Magistrate Eisenbrown startled the little group of court habitues in his office by making this offer to John E. Carroll yesterday, after he had fixed bail at $1000 for Carroll's appearance in court.

Carroll is the inventor of the "carbon-dioxide engine," which he is exploiting through the CO_2 Development Company, and which he asserts will revolutionize power production. The charge against him is that he obtained money under false pretenses. It is alleged that he procured chattels, money and securities valued at upward of $5000 by false representations from Frank T. Richter, of 22 South Fifteenth street, who is now prosecuting him. He is also alleged to have procured $10,000 in cash from William Spencer, of 234 West Johnson street, Germantown, for the exclusive rights to run automobiles with the Carroll engine in Pennsylvania.

After a preliminary hearing on September 28, Magistrate Eisenbrown had Dr. Edwin J. Houston, the electrical expert, investigate Carroll's invention. Dr. Houston reported that he did not believe Carroll's scheme would accomplish what he said it would.

Carroll did not accept the magistrate's offer.—*The North American*, Philadelphia.

[This is the "invention" for calling which "a clumsy mechanical fake" the editor of Power is under indictment.—Editors.]

A Great Gathering of Engineers

The largest social gathering of engineers in the history of the craft in the Borough of Brooklyn, N. Y., took place at the Imperial on Saturday evening, October 10. Many representative engineers of the greater city were present. The committee had arranged for a first-class smoker and vaudeville, which latter was given by the famous "bunch," and, as usual, was of a high standard of excellence. Among the distinguished guests who were heard from during the evening were W. J. Reynolds, national vice-president; Thomas Cole, national conductor, and Fred L. Johnson, past State president of Massachusetts Association, N. A. S. E. There were refreshments of all kinds, and the "good nights" came with reluctance.

We have received from the American Engine Company, Bound Brook, N. J., a 16-page "Political Atlas," with paper covers, containing a "compendium of facts and figures, platforms and portraits of the men and the issues of the Presidential campaign of 1908." Aside from the company's advertisements on the back cover and on the inside of both covers, there is nothing of an advertisement character about the pamphlet, which is 11⅜x14⅛ inches in size. Besides portraits and sketches of all our Presidents beginning with Washington, there are portraits and biographical data of the Presidential candidates of the two great parties, a colored political map, platforms of both parties, in full, data about past Presidents and their cabinets, statistics of past electoral and popular votes, a half-tone view of the Capitol and a full-page chart illustrating, by means of a curve, the "ups and downs" of the American tariff from 1791 to 1901, inclusive. Outside of an encyclopedia we have never seen a volume of pertinent election data compiled in such a handy manner, and we have no doubt the American Engine Company will gladly send a copy of the atlas upon application.

Business Items

J. A. J. Shultz, president of the Shultz Belting Company, has been elected president of the Missouri Manufacturers' Association.

The Wheeler Condenser and Engineering Company, of Carteret, N. J., has appointed Harry Pennington, Lumberman's National Bank building, Houston, Texas, agent for the company in the State of Texas.

The Woodward Furniture Company, Owosso, Mich., has been using Buckeye boiler skimmers in its boilers for some time and says its boilers are in as good shape as the day they were installed. The skimmer is made by the Buckeye Boiler Skimmer Company, South End, Toledo, Ohio.

The Bird-Archer Company, 90 West street, New York, has issued a 48-page treatise on "Boiler Troubles and Their Prevention," in which are explained corrosion, scale, oil and grease deposits and what harm they might do. It further discusses the different methods of water and scale treatment and gives advice on feeding boiler compounds, the care of blow-off valves, etc. A copy may be had free by sending for it.

In these days of aids to memory, memoranda, "ticklers" and other adjuncts of systemization, the title "The Way to Forget," is striking. That is the reason Jay Wellington Hull adopted it for a little pamphlet which he has recently got out for the Triumph Electric Company, of Cincinnati. The idea is that when one uses apparatus that is all right he forgets all about it in the same way that one forgets that he has a stomach, until it goes wrong.

R. G. Davis has, owing to ill health, retired from the firm of Geo. H. Ward & Co., engineers and machinists, 78 Delevan street, Brooklyn, N. Y. His interest has been acquired by Robert Langlotz, who will at once become active in the affairs of the firm. Mr. Langlotz is peculiarly fitted for the work in which Geo. H. Ward & Co. are engaged, as he has had a lengthy experience covering a wide field, from marine engineering to construction and installation work. He is a practical machinist, having been with W. & A. Fletcher Company years ago; was for some time a marine engineer and has had years of power station, mill and manufacturing practice and a large executive business experience.

New Equipment

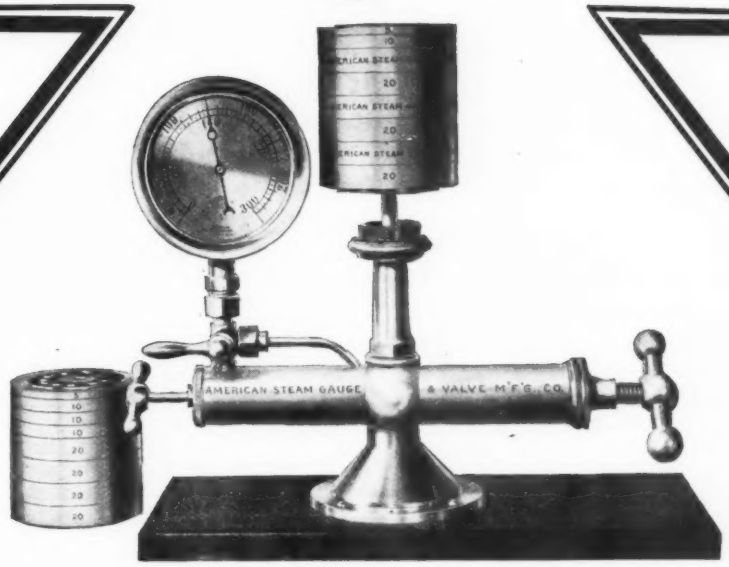
The city of Quitman, Ga. will install two new boilers in power plant.

The Norman (Okla.) Ice Company will rebuild plant recently destroyed by fire.

The city of Decatur, Ga., has voted $15,000 bonds for extending water works.

The plant of the Momence (Ill.) Electric Light Company was destroyed by fire.

The American Dead Weight Tester



¶ This instrument is worth many times its cost in any steam plant and it will quickly pay for itself by reducing the consumption of fuel.

¶ For instance, if a steam gauge registers 80 pounds when in reality you are carrying 90 pounds of pressure, this device shows up the fact plainly and beyond dispute.

¶ You can then make the necessary adjustments and the coal consumed to carry that extra 10 pounds is afterwards saved.

¶ Let us send you our new general catalog, which fully describes this device and other specialties.

¶ Sent free on request.

American Steam Gauge & Valve Mfg. Co.,

208-220 Camden Street, Boston, Mass.

New York, 26 Cortlandt St. Atlanta, 835 Equitable Bldg. Chicago, 7-9 So. Jefferson St.

Pittsburg, Frick Bldg. Annex
Montreal, 444 St. James Street
San Francisco, 247 Pine Street
Los Angeles, 213 So. Angeles Street

When ordering gauges, valves, indicators and kindred appliances for governing, indicating, measuring, recording and controlling steam, air, gas, oil, ammonia and all other pressures, be sure to specify those manufactured by us. Your interest can be best served by the protection they afford.

John Kloss, Wheeling, W. Va., is having an addition erected to be used as an ice manufacturing plant.

The city of Juliette, Ga., is considering issuance of bonds to construct an electric light plant and water works.

It is reported that the Water Commissioners of Erie, Penn., will shortly award contract for a new pumping engine.

H. E. Havens, Girard building, Philadelphia, Penn., has been granted permit to erect a power house for the Girard estate.

It is said that the Greenville (Ky.) Light and Water Company will issue $12,000 bonds for improving water works system.

Fred A. Howe, Huntsville, Ala., has been granted a franchise to construct an electric lighting plant at Stevenson, Ala.

The Metropolitan Electric Company, Reading, Penn., intends, it is said, to erect a new power house at a cost of over $1,000,000.

Plans have been prepared for two power houses to be erected at Newton Falls for the Peerless Electric Company, of Warren, Ohio.

The Kansas-Colorado Electrical Transmission Company is having plans prepared for its proposed power house at Garden City, Mo.

The power house of the Albany & Hudson Railroad at Stuyvesant Falls will be enlarged. Improvements will cost about $75,000.

It is reported that the municipal electric light and water plant at Waverly, La., recently destroyed by fire, will be rebuilt at once.

The City Council of Manhattan, Kan., has granted a franchise to W. R. West and J. T. West, of Kansas City, to build an electric railway.

Plans are being prepared by Samuel Lozier, Hackensack, N. J., for the construction of waterworks at Lodi, N. J. About $80,000 will be expended.

The Philmont (N. Y.) Lighting and Power Company has applied for permission to issue $7000 bonds for the purpose of making improvements to plant.

The Brunner Water and Light Company has been granted franchise by the County Commissioners of Houston, Texas, to erect a water and light plant.

The Erie Railroad Company will construct a reservoir and pumping station at Middletown, N. Y. T. L. Stuart, 11 Broadway, New York, is chief engineer.

The Tioga Traction Company is being formed to construct an electric railway from Mansfield to Wellsboro, Penn. W. A. Selts, Jersey Shore, Penn., is interested.

Bids will be received at the City Hall, Helena, Mont., until noon, October 29, for the construction of water works system. Plans can be seen at the office of J. A. Mattson, city clerk.

It is reported that the Syracuse, Lake Shore and Northern Railroad Company, Syracuse, N. Y., will erect two power houses, one near Fulton and the other near Phoenix, N. Y.

The West End Water Company, Clarksburg, W. Va., has been incorporated with $20,000 capital to construct water works system. O. B. Lawman, F. I. Day and others, incorporators.

The Rochester, Corning & Elmira Traction Company will build an electric railway between Rochester, Corning and Elmira. L. Feuerstein, 27 Church street, Rochester, N. Y., is engineer.

The Commissioner of Public Works, Buffalo, N. Y., will have plans and specifications prepared for the installation of an engine and generator at the Hamburg canal pumping station.

The Fresno, Hanford & Summit Lake Interurban Railway has completed surveys and will shortly commence construction. Main power plant will be at Kingsburg, Cal., and substations at Malaga and Laton. L. A. Nares, of Fresno Cal., is president.

Help Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn St., Chicago.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

CHIEF ENGINEER of large industrial plant desires change; active and alive, an expert with indicators and testing apparatus, can keep operating expenses at proper figures. Box 27, POWER.

MECHANICAL ENGINEER, age 25, desires employment with growing manufacturing company. Experience in general engineering, sales and office work. Moderate salary. "Engineer," POWER.

AN ENGINEER, having excellent record, one who has never caused a breakdown, whose references are gilt edged, who attends exclusively to his own business, does not drink and would not join union if he was paid for it, is desirous of making a change for good reasons. Box 50, POWER.

Miscellaneous

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—A large pumping station for pumping natural gas. Inquire Pittsburgh Plate Glass Company, Room 1624, Frick Building, Pittsburg, Pennsylvania.

PATENTS secured promptly in the United States and foreign countries. Pamphlet of instructions sent free upon request. C. L. Parker, Ex-examiner, U. S. Patent Office, McGill Bldg., Washington, D. C.

MECHANICAL ENGINEER, technical graduate, manufacturing and sales experience East and West, would be glad to hear from engineers or manufacturers wishing representation in the Northwest. Box 49, POWER.

NEW BRITISH PATENTS ACT. A manufacturing firm, possessing extensive and well equipped engineering works in the English Midlands, invites inquiries from American firms desirous of arranging for the manufacture in England of patented mechanical or electrical specialties to comply with the requirements of the above Act now in force. Apply, in first instance, to C. M. Stevenson, 29 Broadway, N. Y.

For Sale

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—Electric light plant, growing town; 700 lights now in use. Price $6000.00. Reasons for selling, other business. Address Box 50, Giddings, Texas.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE—One 24x48 Fraser & Chalmer Corliss engine in good running order. We invite inspection at our plant, where engine can be seen under full working conditions. Delivery during December. Carr, Ryder & Adams Co., Dubuque, Iowa.

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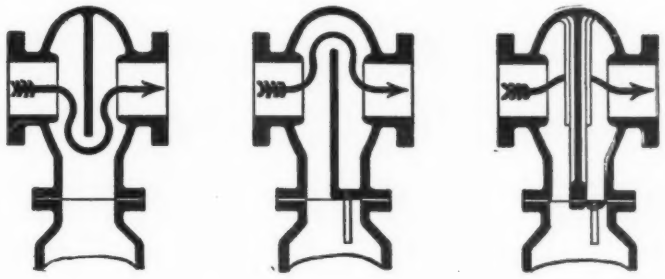
COCHRANE SEPARATORS

UNDER, OVER OR AROUND

How shall the steam get by the baffle placed to intercept the flying particles of water or oil? One way is better than all the others. Let us explain:

Suppose the steam passes under the baffle, then when the water or oil runs down off the lower end of the baffle it will fall into a swift current of steam and will be licked up again into the outlet pipe; therefore the under way should never be used. Nevertheless, it is the method employed by a host of cheap, so-called separators.

Next, suppose that the steam current leaps up over the baffle? This is a little better, but here, again, we are putting difficulties in the way of the water and oil particles by requiring them to fall out of the steam against the current. Both the over and the under arrangements, it will be noted, have a tendency to constrict the passage for steam around the baffle.



Now, consider the arrangement in which the current goes around the baffle horizontally. In the Cochrane it goes around on either side, both to the right and to the left, and being divided into two parts, the current is only one half as deep; therefore, flying particles are required to shoot through only half as great a distance before they strike the baffle as would be required in the other forms. Moreover, as the ribs on this baffle are vertical, the particles run down readily into the well, which would not be the case if the ribs were inclined or horizontal. A drain for any condensation that occurs in the chamber on the outlet side of the baffle extends nearly to the bottom of the receiver, and the barometric column thus provided insures that the water will always run down into the well.

For a summary of the various points about separator design, see our Treatise "15-S."

HARRISON SAFETY BOILER WORKS,
17TH & CLEARFIELD STS., PHILADELPHIA, PA.

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Scully Steel & Iron Co., Chicago, Ill.
Union Steam Pump Co., Battle Creek, Mich.
Westinghouse Traction Brake Co., Pittsburg, Pa.
York Mfg. Co., York, Pa.

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McLeod & Henry Co., Troy, N. Y.
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Arch, Boiler

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Arch, Boiler Door

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Presbrey Fire Brick Co., Taunton, Mass.

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Belting, Rubber

Bowers Rubber Works, Oakland, Cal.

Benders, Hydraulic

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Pittsburgh Gage & Supply Co., Pittsburgh, Pa.
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Blocks, Chain

Yale & Towne Mfg. Co., New York.

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Sturtevant Co., B. F., Hyde Park, Mass.
Wing Mfg. Co., L. J., New York.

Blowers, Furnace

McClave-Brooks Co., Scranton, Pa.

Boiler Skimmers

Buckeye Boiler Skimmer Co., Toledo, Ohio.

Boilers, Second Hand

Wickes Boiler Co., Saginaw, Mich.

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Keeler & Co., E., Williamsport, Pa.
Kewanee Boiler Co., Kewanee, Ill.
Oil Well Supply Co., Oswego, N. Y.
Struthers-Wells Co., Warren, Pa.
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Wickes Boiler Co., Saginaw, Mich.

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Books

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Presbrey Fire Brick Co., Taunton, Mass.

Building Materials, Fireproof

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Cement, Asbestos

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Chimneys

Weber Co., Chicago, Ill.
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Wiederholdt Construction Co., Chicago, Ill.

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McCrea & Co., James, Chicago, Ill.

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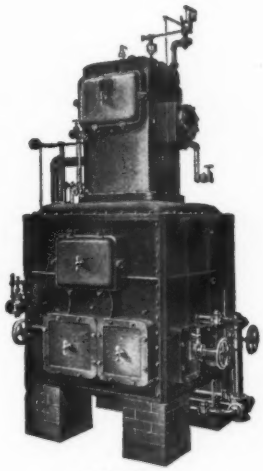
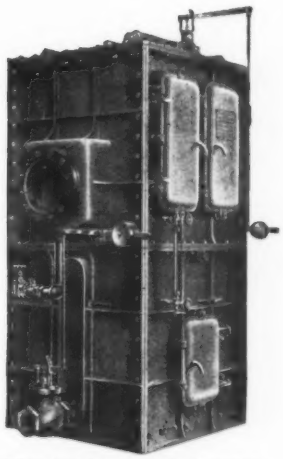
We can show you **how** our Heaters get highest temperature of feed water, how they use **just enough** exhaust to do it, how they cost less to maintain—and why there are now over 2,250,000 h. p. in **successful use.**



Webster
Chemical Purifier

Webster Heaters



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If your water supply is particularly bad, we can prove to you that the Webster Chemical Purifier will treat it **while hot** and send it into your boilers not only perfectly pure and "healthy" but also at the highest possible temperature.

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Your time is worth no more than our reputation—the latter insures you against wasting the former.

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CAMDEN, NEW JERSEY

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Dearborn Drug & Chemical Co., Chicago, Ill.
Hawk-Eye Compound Co., Chicago, Ill.
Johns-Manville Co., H. W., New York.

Compound, Lubricating

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Providence Eng. Works, Providence, R. I.
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Foos Gas Engine Co., Springfield, O.
Fort Wayne Fdry. & Mach. Co., Ft. Wayne, Ind.
Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Riverside Engine Co., Oil City, Pa.
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Westinghouse Machine Co., Pittsburg, Pa.

Engines, High Speed

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Bates Machine Co., Joliet, Ill.
Buckeye Engine Co., Salem, Ohio.
Clark Bros. Co., Belmont, N. Y.
Engberg's Electric & Mechanical Wks., St. Joseph, Mich.

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Shepherd Engineering Co., Williamsport, Pa.
Skinner Engine Co., Erie, Pa.
Southwark Foundry & Machine Co., Philadelphia, Pa.
Watertown Engine Co., Watertown, N. Y.
Westinghouse Machine Co., Pittsburg, Pa.

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American Diesel Engine Co., New York.
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Minneapolis Steel & Mach'y Co., Minneapolis, Minn.
Shepherd Engineering Co., Williamsport, Pa.
Skinner Engine Co., Erie, Pa.
Southwark Foundry & Mach. Co., Philadelphia, Pa.
Westinghouse Machine Co., Pittsburg, Pa.

Engines, Oil

American Diesel Engine Co., New York.
De La Vergne Machine Co., New York.

Engines, Rotary

Ball-Cooley Engineering Co., New York.

Engines, Steam

Ball & Wood Co., Elizabethport, N. J.
Ridgway Dynamo & Engine Co., Ridgway, Pa.

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General Electric Co., Schenectady, N. Y.
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Westinghouse Elec. and Mfg. Co., Pittsburg, Pa.

Fans, Exhaust and Ventilating

Ohio Blower Co., Cleveland, O.
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Fans, Mine Ventilating

Jeffrey Mfg. Co., Columbus, O.

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Davis Regulator Co., G. M., Chicago, Ill.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
Lunkenheimer Co., Cincinnati, O
Myers & Bro., F. E., Ashland, O
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

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Eclipse Feed Water Heater and Purifier Co., Appleton, Wis.
Keystone Chemical Co., Philadelphia, Pa.

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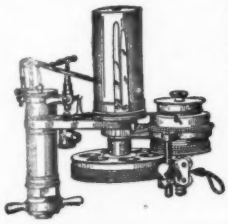

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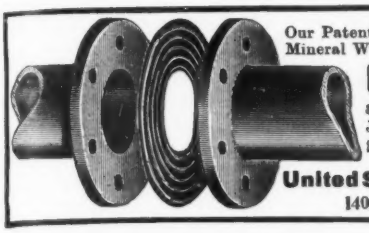

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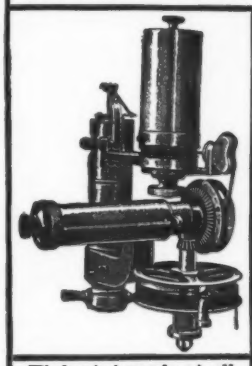

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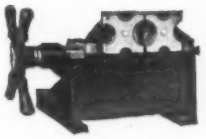

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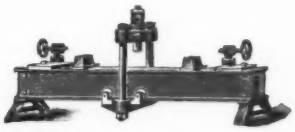

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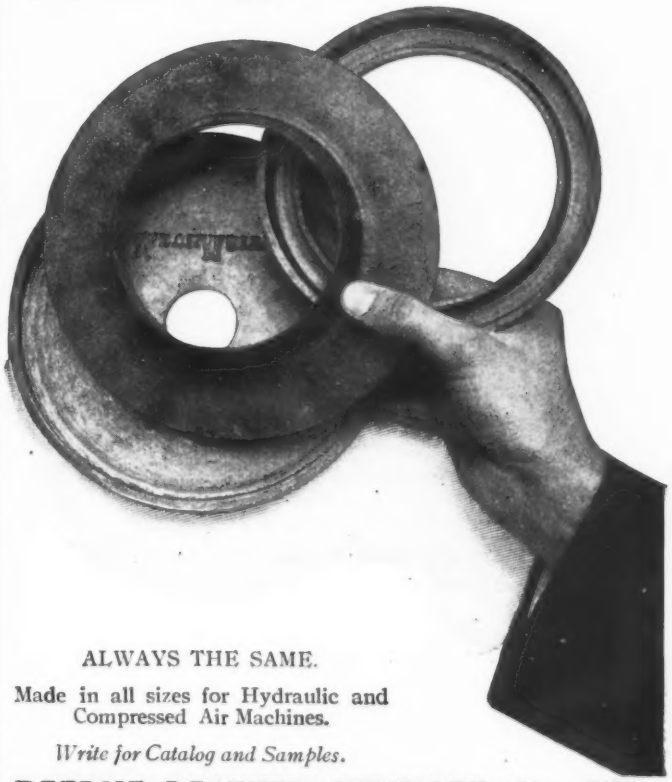

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Watson-Stillman Co., New York.

Pumps, Mining

American Steam Pump Co., Battle Creek, Mich.

Pumps, Oil

American Steam Pump Co., Battle Creek, Mich.
Deming Co., The, Salem, O.
Detroit Lubricator Co., Detroit Mich.
Du Bois Iron Wks., Du Bois, Pa.
Lunkenheimer Co., Cincinnati, Ohio.
Penberthy Injector Co., Detroit, Mich.
Pittsburgh Gage & Supply Co., Pittsburg, Pa.

Pumps, Pressure

Deane Steam Pump Co., Holyoke, Mass.

Pumps, Steam

American Steam Pump Co., Battle Creek, Mich.
Blake Mfg. Co., Geo. F., New York.
De Laval Steam Turbine Co., Trenton, N. J.
Du Bois Iron Works, Du Bois, Pa.
Gardner Gov. & Sep. Co., Quincy, Ill.
McGowan Co., John H., Cincinnati, O.
Myers & Bro., F. E., Ashland, O.
Stewart Heater Co., Buffalo, N. Y.

Pumps, Steam—*Continued.*

Union Steam Pump Co., Battle Creek, Mich.
Wheeler Cond. & Eng. Co., New York.

Pumps, Triplex

Deming Co., The, Salem, O.

Pumps, Turbine

Alberger Condenser Co., New York.
Worthington, Henry R., New York.

Pumps, Vacuum

American Steam Pump Co., Battle Creek, Mich.
Warren Steam Pump Co., Warren, Mass.
Wheeler Condenser & Engineering Co., New York.

Punches, Hydraulic

Watson-Stillman Co., New York.

Purifiers, Live Steam

Hoppes Mfg. Co., Springfield, O.

Purifiers, Water

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Crosby Steam Gage and Valve Co., Boston, Mass.

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Crosby Steam Gage & Valve Co., Boston, Mass.
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Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Kitts Mfg. Co., Oswego, N. Y.
Lagonda Mfg. Co., Springfield, O.
Robertson & Sons, Jas. L., New York.
Watson & McDaniel Co., Phila., Pa.

Regulators, Feed Water

American Boiler Economy Co., Philadelphia, Pa.
Berry Engineering Co., Chester, Pa.
Chaplin-Fulton Mfg. Co., Pittsburg, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Phila., Pa.

Regulators, Pressure

American Boiler Economy Co., Philadelphia, Pa.
Davis Co., John, Chicago, Ill.
Davis Regulator Co., G. M., Chicago, Ill.
Dean Bros. Steam Pump Works, Indianapolis, Ind.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Marshalltown, Iowa.
Mason Regulator Co., Boston, Mass.
Olfio Brass Co., Mansfield, O.
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Strong, Carlisle & Hammond Co., Cleveland, O.
Watson & McDaniel Co., Phila., Pa.

Regulators, Temperature

d'Este Co., Julian, Boston, Mass.

Repairs, Engine and Pump

Underwood & Co., H. B., Philadelphia, Pa.

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Garlock Packing Co., Palmyra, N. Y.
Greene, Tweed & Co., New York.
Mercer Rubber Co., Hamilton Square, N. J.
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New York Belting & Packing Co., New York.
Peerless Rubber Mfg. Co., New York.
Quaker City Rubber Co., Phila., Pa.
Restein Co., Clement, Phila., Pa.

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American School of Correspondence, Chicago, Ill.
International Correspondence Schools, Scranton, Pa.

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Beggs & Co., Jas., New York
d'Este Co., Julian, Boston, Mass.
Direct Separator Co., Syracuse, N. Y.
Goubert Mfg. Co., New York.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburg, Pa.
Ohio Blower Co., Cleveland, O.
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Pittsburgh Gage & Supply Co., Pittsburgh, Pa.
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Harrison Safety Boiler Works, Philadelphia, Pa.
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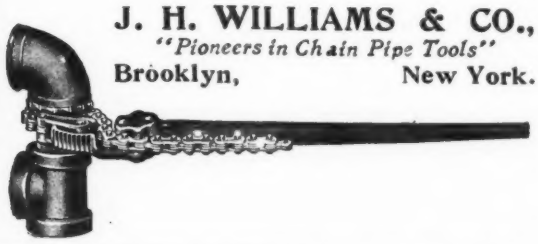

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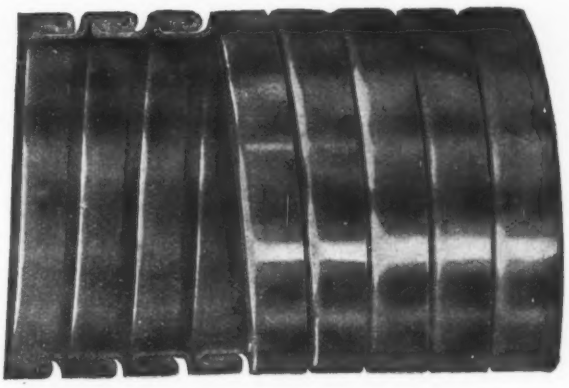

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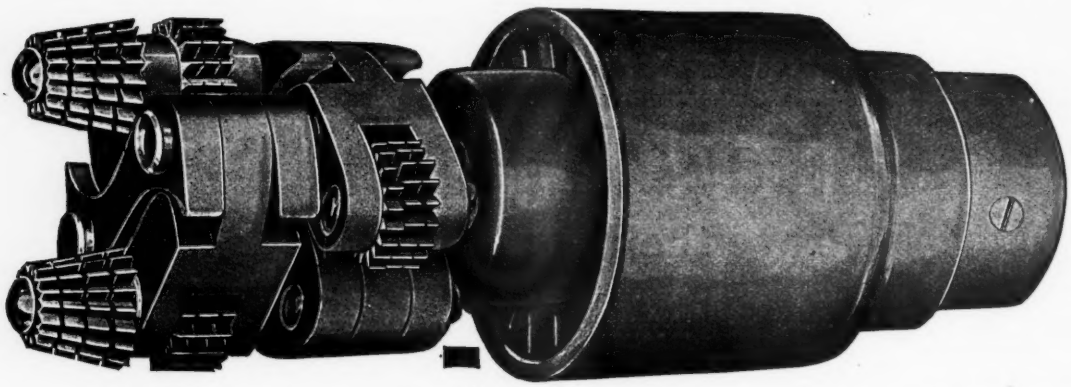

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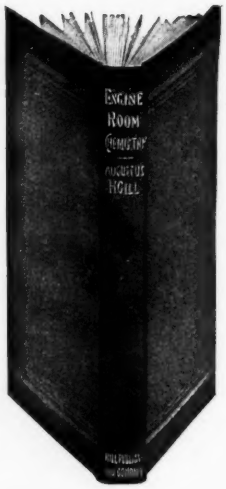

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TWIN STRAINERS

LIBERTY OIL PURIFIER

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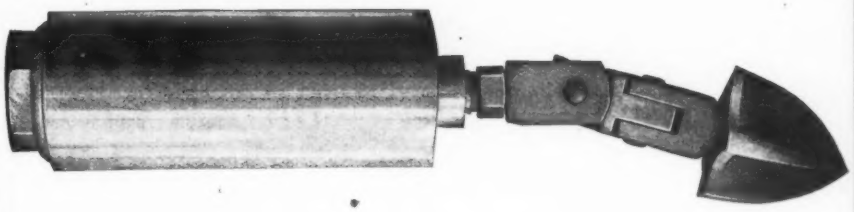
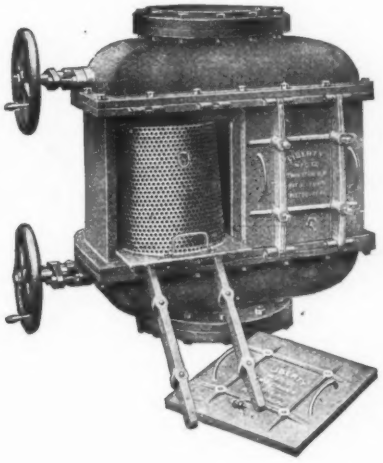
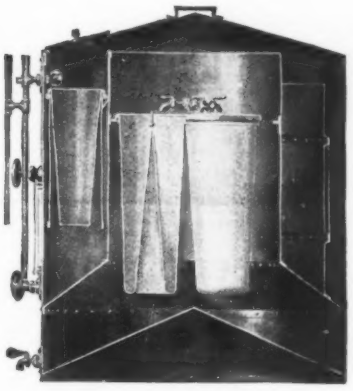
A STRAIGHT TICKET FOR LIBERTY



The best of other cleaners can clean but one tube while the Liberty is cleaning **two.** We guarantee the Liberty to remove the thickest scale without injury to the tubes. No matter if your tubes are practically closed up, the Liberty will render them "clean as a whistle."



With other strainers, your pump or pipe line is just as likely as not to clog up during those few minutes the strainer is idle while being cleaned. The Twin Strainer, however, strains continuously; either side performing the work while the other side is idle.



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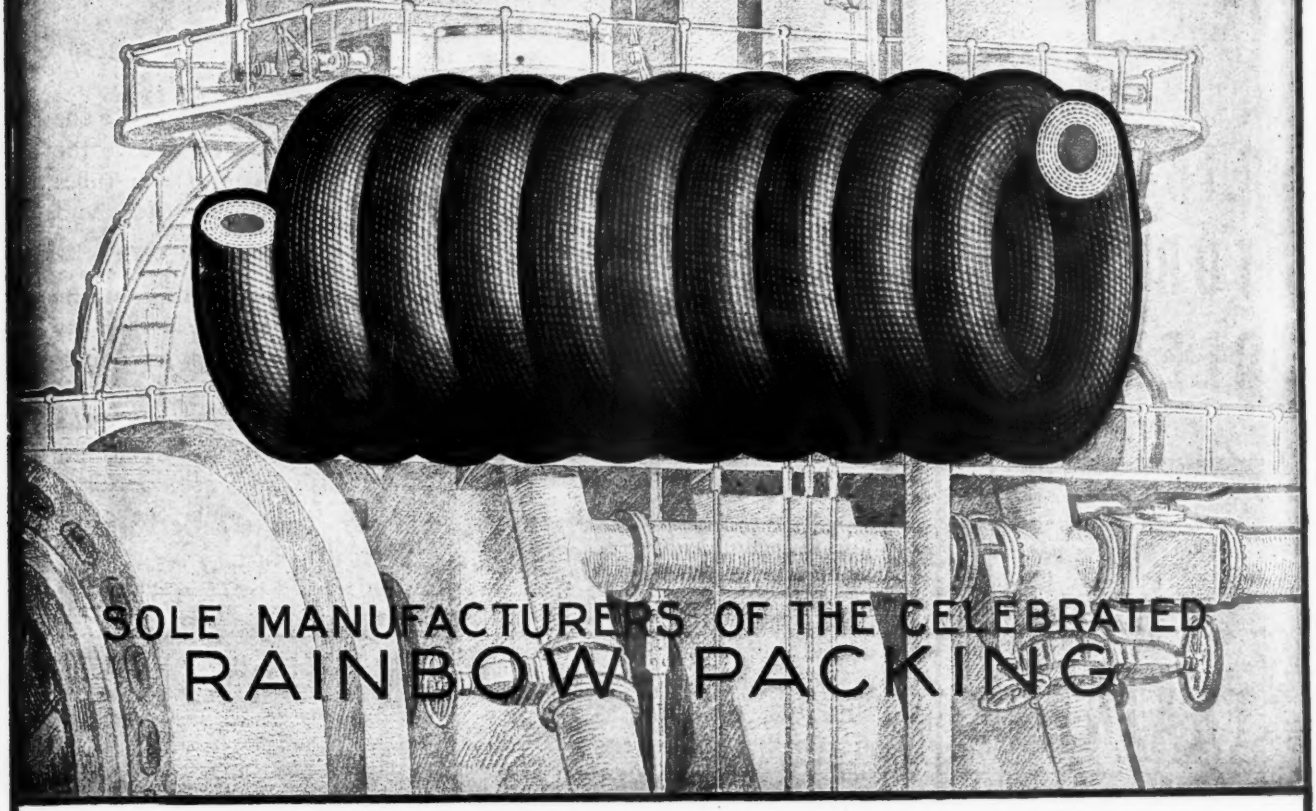

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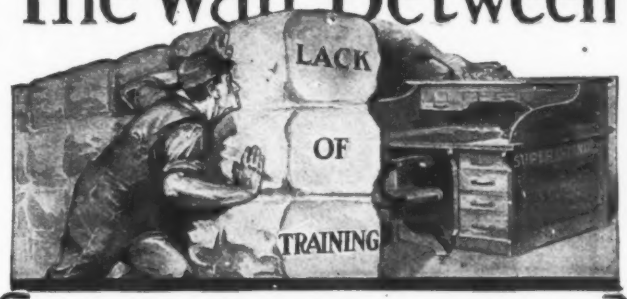

There's a high stone wall between the untrained worker and the man with **special training;** between the daily bread wages and a good salary; between being "one of the **hands**" and "one of the **heads**" of a business.

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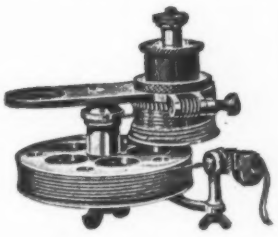

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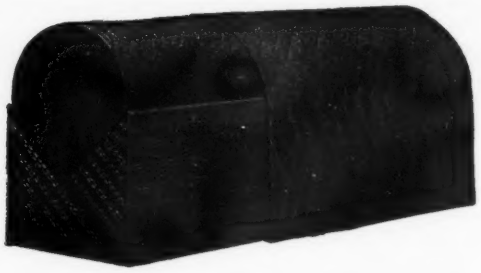

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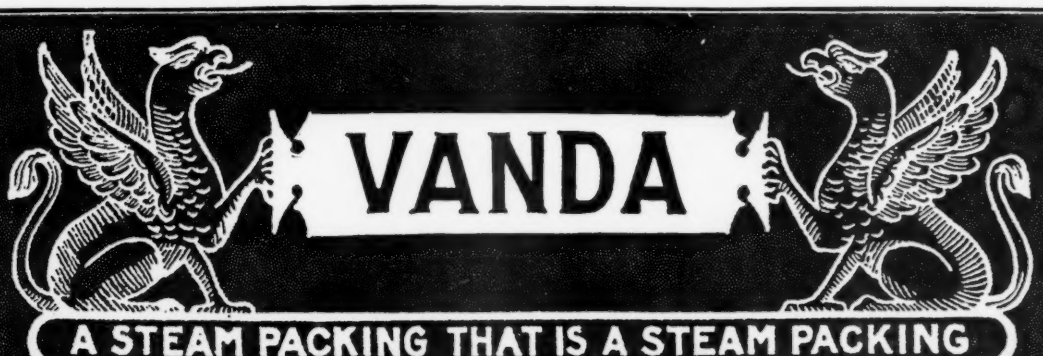

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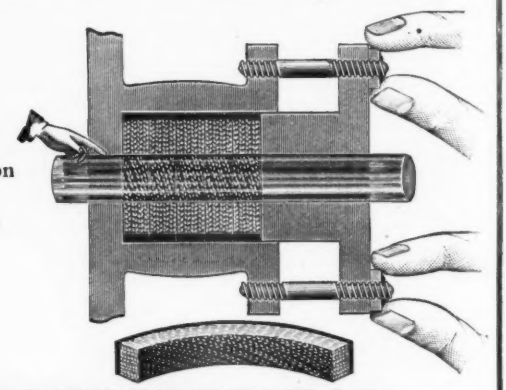
is best as there is a *give* that can be *taken up* as the packing wears.

It is this **Diagonal** construction that gives Compressibility.



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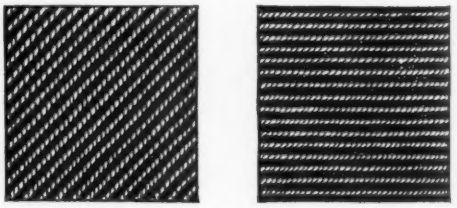

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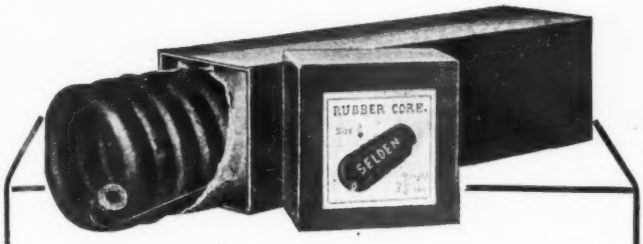

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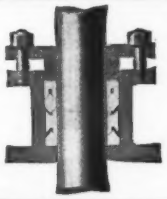

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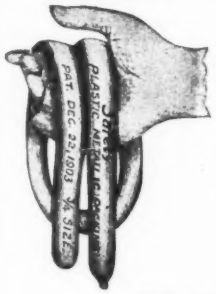

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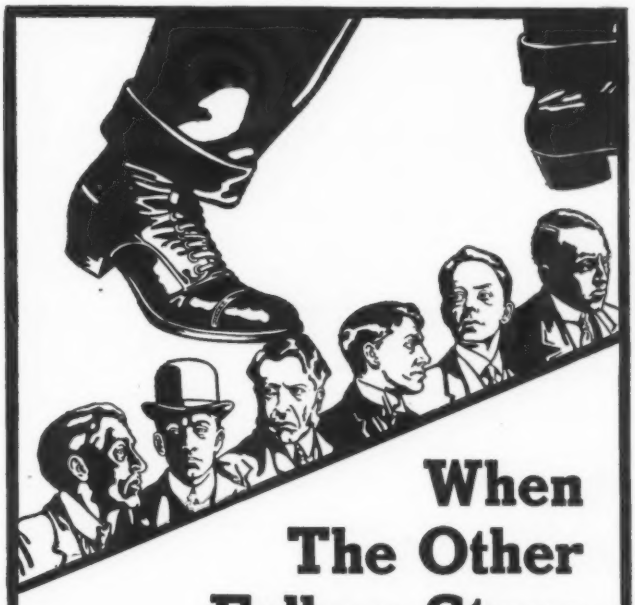

When The Other Fellow Steps Over Your Head

Yes, it does jar you to have some other fellow step over your head and take possession of the job you've had your eyes on for some time—to say nothing of money that goes with it.

But why does this happen?

A little thinking brings you face to face with the undeniable fact that **training** is responsible for it—that while you were **waiting** for opportunity, trusting to luck for promotion, the other chap was **making** his opportunities by preparing himself for positions ahead.

To advance you must have the practical training that makes you an expert. No man can expect to get a higher position if he has not the ability to competently hold that position.

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The I. C. S. brings a six-million-dollar equipment and an experience of nearly 17 years in the sole business of salary-raising training to the personal advancement of every one of its students. It assists these men in their own homes, in their spare time, and at a cost arranged to suit their own individual circumstances. It overcomes all obstacles of lack of time, money, or education, and secures for poorly paid wage earners such advancement as they never even hoped for before. What the I. C. S. has done for thousands of other men it can do for **YOU.**

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Civil Engineer	Foreman Blacksmith	Chemist
Bridge Engineer	Marine Engineer	Sheet-Metal Draft.
Mechanical Eng.	Hydraulic Engineer	Ornament. Designer
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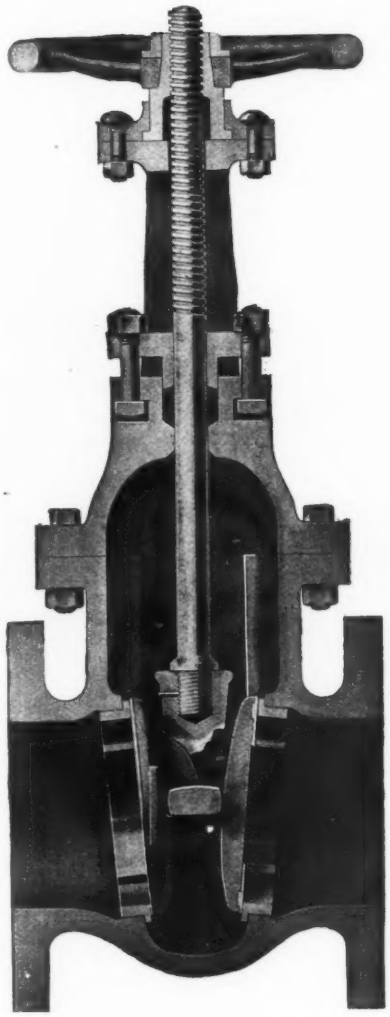

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Four More Advantages in Nelson Valve Construction

Packed When Open. When the valve is wide open, the convex shoulder of the stem collar makes a tight joint in the concave recess of the bonnet directly under the packing chamber, and holds the pressure during the packing operation.

Deep Stuffing Boxes with large packing chamber to give better and longer service.

Ample Bolting Room, allowing liberal space for play of wrench, makes the bolting up of flanges an easy job.

Full Weight Flanges that give generous margins of strength for stress, strain or shock caused by varying pressures, or other hard conditions of service.

Drilled Bolt Holes In Bonnets that match, even when position of bonnet is reversed.

In Nelson Valves every advantageous detail is efficiently embodied; we therefore can and do guarantee them—absolutely and expressly.

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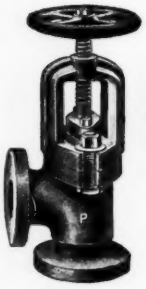

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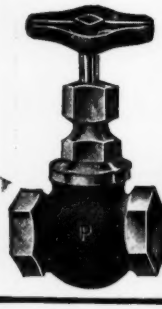

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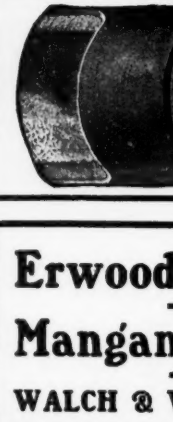
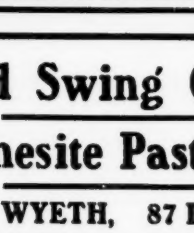
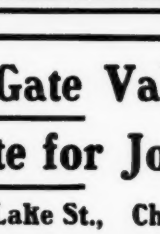
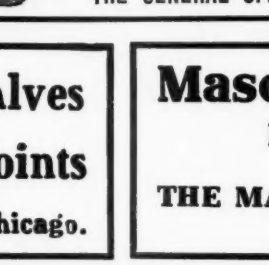
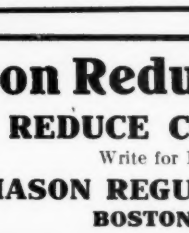

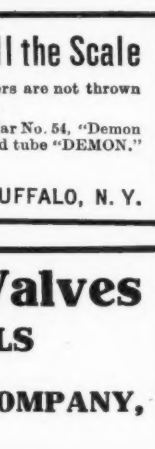

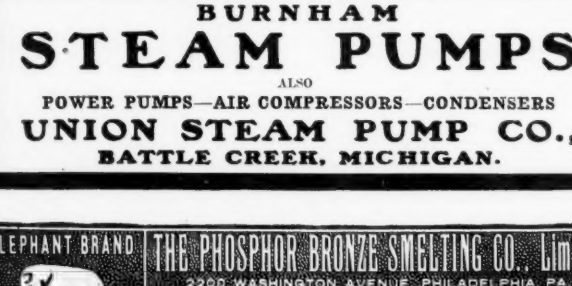

A Water Tube Cleaner Which Must Get All the Scale

Here is the front half of "DEMON" cleaner. Notice that its cutters are not thrown out by Centrifugal action but are *held fixedly* to the full size of tube.

Every tube *must* be cleaned perfectly. Don't fail to write for circular No. 54, "Demon Cleaners vs Other Cleaners." Circular No. 56 describes the curved tube "DEMON." Folder No. 30 tells about the "TORPEDO" fire tube cleaner.

THE GENERAL SPECIALTY CO., 887 Niagara St., BUFFALO, N. Y.

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If You Want Satisfaction Buy Homestead Valves

The Four-Way type, shown here, is unequalled for operating hydraulic and pneumatic machinery of all kinds, and many other purposes. It always works perfectly and can be depended upon for wonderful durability. Booklet?

Homestead Valve Mfg. Co.

Pittsburg, Pa., U. S. A.

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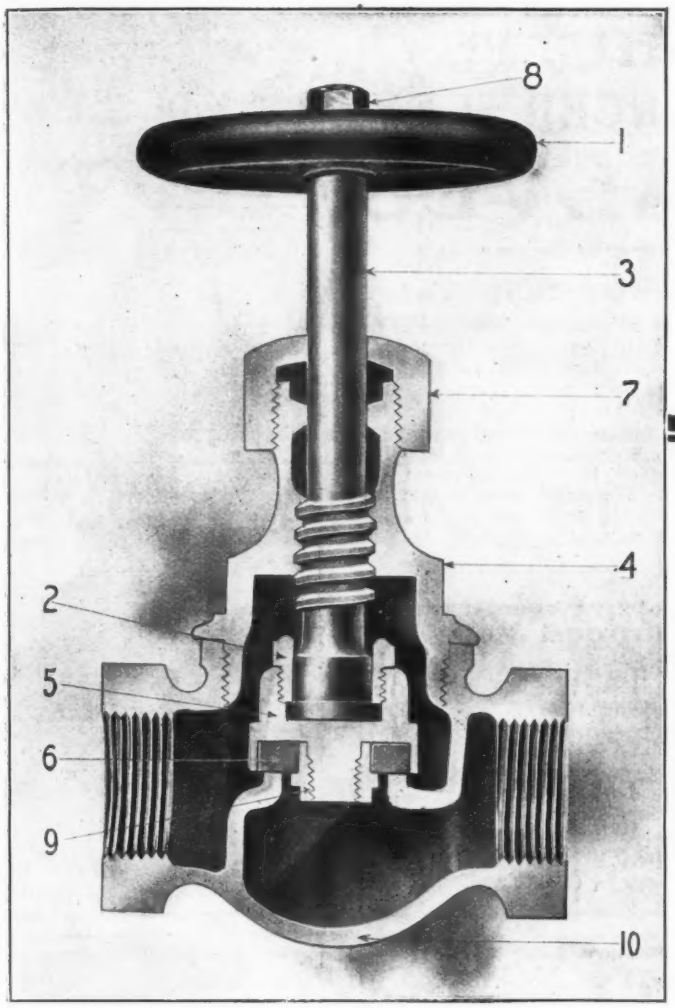

From Wheel Nut to Body

each and every component part of a Jenkins Bros. Valve is designed to meet the requirements of the most exacting every-day service. In design, in metal and in workmanship care has been taken to produce a valve that will give maximum amount of strength and durability. Every part is made to gauge, and if any part requires renewal the necessary repair part can be readily obtained either direct or through any dealer at nominal cost.

Description of Parts

1. Wheel	4. Bonnet	8. Wheel Nut
2. Lock Nut	5. Disc Holder	9. Disc Nut
3. Spindle	6. Disc	10. Body
	7. Waste Nut	

Jenkins Bros. Valves

are made in brass and iron body in various designs, both Standard and Extra Heavy Patterns for working steam pressures up to 150 pounds and 250 pounds respectively. The cut gives a sectional view of the Standard Pattern Brass Globe Valve, Screwed. Among the other styles of Jenkins Bros. Valves are Angle, Cross, Horizontal Check, Swing Check, Combination Stop and Check, Whistle, Y, Safety, Radiator, and a new line of Medium Pressure and Extra Heavy Gate Valves.

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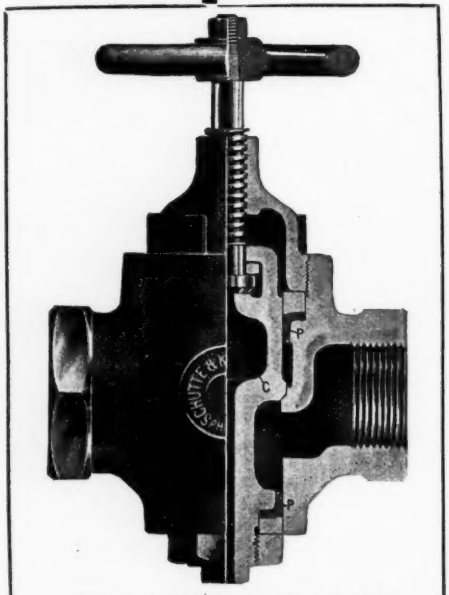
SCHUTTE
HYDRAULIC, BALANCED, LEVER AND GATE
VALVES



Balanced Hydraulic Stop Valve

Hydraulic Stop Valve

This valve is balanced above and below the seat and will close if flow is from above or below seat, therefore immaterial how placed in pipe line.

Like all "Schutte" valves, it has full pipe area, made of the best of new metal, suitable for a working pressure of 1500 lbs., and guaranteed to withstand 3000 lbs. per sq. in. We make stop valves for pressures from 250 lbs. to 3000 lbs.

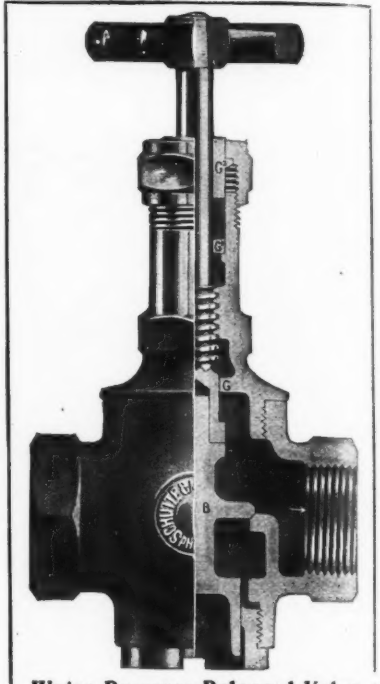
Write for Catalog 8-H.

Water Pressure Balanced Valve

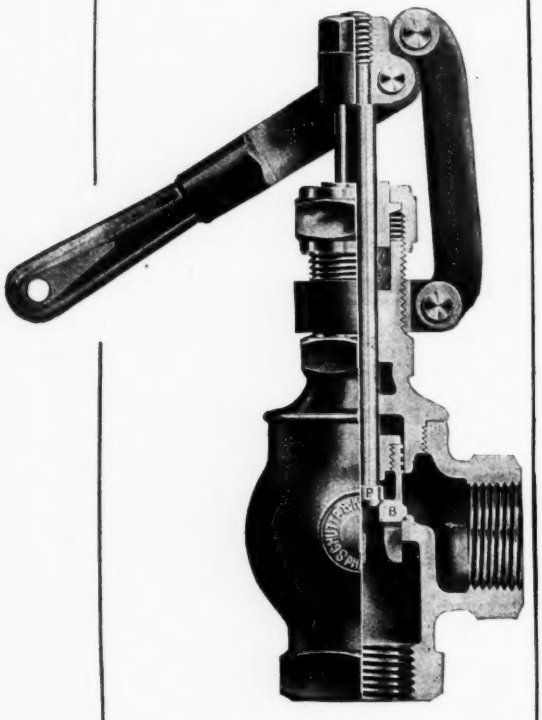
Where blows and jars in the pressure supply pipe occur through the sudden opening or closing of outlets from the same pipe, thereby producing action of a ram, this valve should be installed.

This valve is especially applicable to Injector installations, where supply to injector is under irregular high pressure, At the same time it can be used for a Stop and Regulating Valve.

Write for Catalog 8-A.



Water Pressure Balanced Valve



Quick Operating Lever Valve

Quick Operating Lever Valve

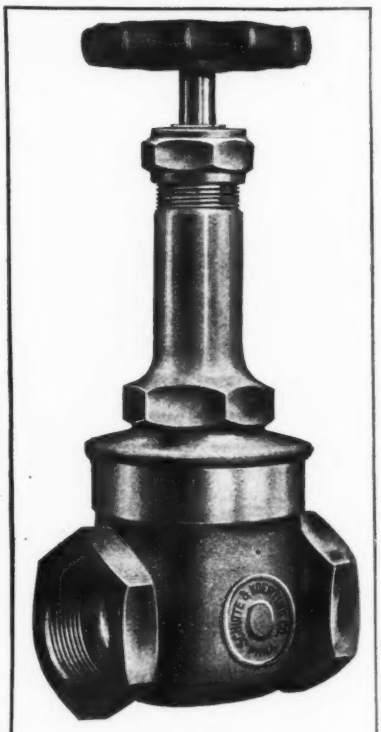
These valves are especially made for conditions where stopping or starting is required *by one quick movement*, such as vacuum breaker, by pass for admitting steam into a low-pressure cylinder when starting engine, for relieving low pressure cylinder when starting, or for relieving low pressure cylinder when starting or reversing. They are used in connection with automatic floats and many other purposes. Admission of pressure must always be above disc. They are made either globe or angle, of hard bronze and nickel bronze, for 250 lbs. steam and of new metal entirely.

Write for catalog 8-A.

Double-Disc Gate Valve

The "Schutte" Gate valve has two discs, the construction of which is so that they are first drawn from the seat before they can begin vertical movement, therefore, no scraping on seat, no tendency to deform body, are easy to operate, friction reduced to a minimum. These valves have been installed in the largest high-pressure steam superheated plants of the country and have proven highly satisfactory.

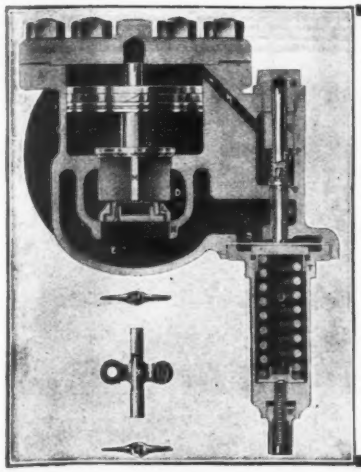
Write for catalog 8-G.



Gate Valve

SCHUTTE & KOERTING CO., Tompson and 12th Sts. PHILADELPHIA, PA.

New York, 50 Church St. Boston, 98 High St. San Francisco, O. C. Goeriz & Co. Chicago, Security Bldg. Pittsburg, Keenan Bldg.



Another Exclusive Feature

of the Collin Steam Pressure Regulating Valve is that the supplementary piston (L) cuts off the velocity of the steam *before* the main valve (J) seats in closing, thus preventing hammering or cutting of the main valve. Other interesting and exclusive features explained in booklet P-B. Write for copy today.

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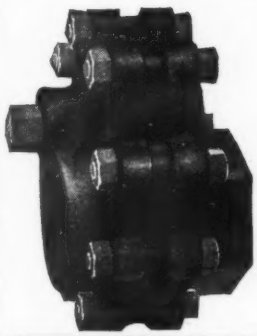
EVERLASTING BLOW-OFF VALVE



Straight-through flow. No stuffing-box. Easily operated. Self-cleaning; self-grinding seats. No repairs needed. Send for descriptive booklet and prices.

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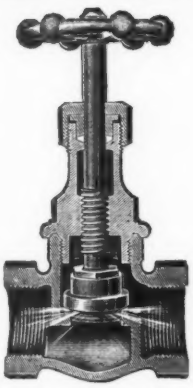
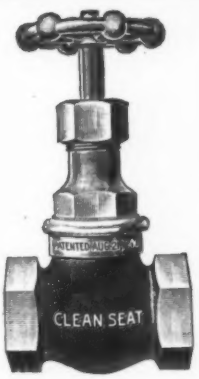
CLEAN-SEAT VALVES





ARE BEST WE SAY SO, AND CAN PROVE IT:

1. A VALVE tightly closed does not wear fast.
2. A VALVE cannot close tight on a dirty seat.
3. A VALVE should be able to keep its seat clean.
4. A VALVE which can do this will wear well.

THE CLEAN SEAT VALVE, every time it closes, throws a strong jet of steam directly across the seat, all the way round, as the disc approaches the seat. This jet blows away all sediment, scale, grit, rust, or other foreign matter, and insures tight closing *every time*, by clean metallic contact between disc and seat.

The "Clean-Seat" principle reduces the wear on seats and discs to a positive minimum and makes easy the ordinarily difficult work of controlling high pressures. For high pressure service this valve makes its most conspicuous showing, and it is made in the following heavy weights:

Medium for pressures up to and including 200 lbs.
Extra heavy for pressures up to and including 500 lbs.
Hydraulic for pressures up to and including 3,000 lbs.

For long, hard and continuous service the "Clean-Seat" Valve has no rival. On this claim, we stand ready to submit conclusive proof, beyond even a reasonable doubt.

PRICES:

Size.....inches	⅛	¼	⅜	½	¾	1	1¼	1½	2	2½	3
Medium.....each	1.10	1.10	1.25	1.60	2.20	2.80	4.00	5.50	8.75	15.75	22.00
Extra Heavy. "	.....	3.00	3.50	4.00	5.00	6.50	8.25	11.00	16.00	33.00	45.00
Hydraulic... "	.....	5.00	5.00	6.00	7.50	10.00	12.50	16.50	24.00	50.00	65.00

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Makes no difference what kind of a Valve you want, how you want it made or where you want it shipped, we can supply it on shortest possible notice.

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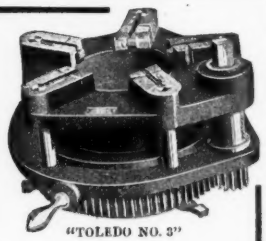
ONE MAN POWER

is all that this machine requires to thread pipe from 4½″ to 8″ inclusive.



"TOLEDO NO. 3"

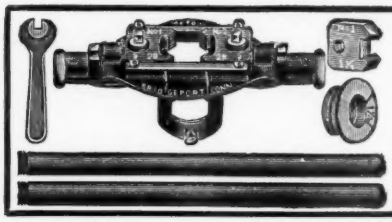
The "Toledo" weighs but 155 lbs. and can be carried to the work, thus saving a great deal of time and labor. Write.

THE TOLEDO PIPE THREADING MACHINE CO.
TOLEDO, OHIO.

The Stulp Automatic Closing Water Gauge
Regrinds Its Own Seat and Cleans Its Way to the Boiler.

Has only one valve for main and check valves. Equally useful for Locomotive, Stationary or Marine Boilers. Never was known to fill up. The approved Gauge by U. S. Government. Special Price, $10.

The Automatic Safety Water Gauge Co.,
FRED J. STULP, Prop. MUSKEGON, MICHIGAN.



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PIPE MACHINES,
PIPE CUTTERS,
VISES.

Manufactured by
The Armstrong Mfg. Co.
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An Incentive to Careful Firing

The Ashton Improved Pressure Recording Gauge makes a permanent written report of any carelessness or omission of duty on the part of the fireman.

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THE ASHTON VALVE COMPANY,
Boston New York Chicago
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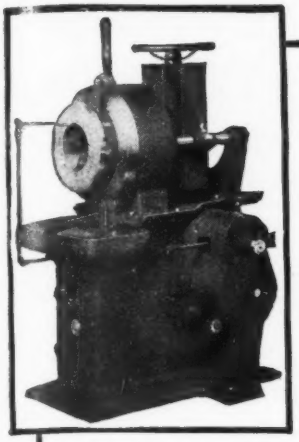

Power Pipe Threading Machinery

Belt—Motor—Gas Engine Driven

Loew Victor Model 1908

Built to take care of same class of work as heavy lathe—bed types, and has the advantage of reduced size (which means lower cost), less floor space, and portability, besides the improved features which are to be found only in the Loew Victor.

Catalog on request.

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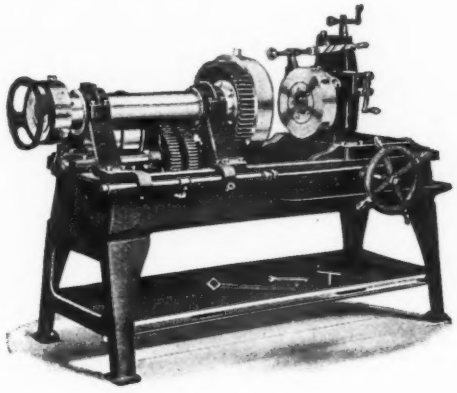
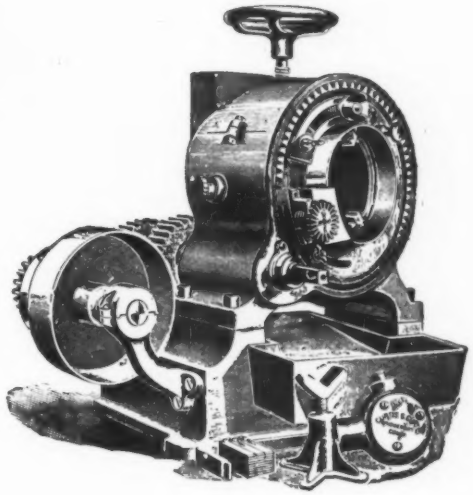


STEP

into most any shop where several makes of pipe machines are installed, and if any are in use, they are B. & K. The workman prefers to run the B. & K. machines because they are easy to operate and always make good threads.

Bignall & Keeler Mfg. Company
Edwardsville, Ill.

Cuts True, Straight, Uniform Threads



The Forbes Patent Die Stock

with one man to operate is more efficient, rapid and economical than any of the two-man machines.

The compensating adjustments of the shell take up the wear on its gears.

The Forbes requires no more space than is necessary to handling the pipe and its receding gears carry the dies on to the pipe.

Catalog?

The Curtis & Curtis Co.

85 Garden Street,
Bridgeport, Conn.

REDUCE THE STEAM AUTOMATICALLY

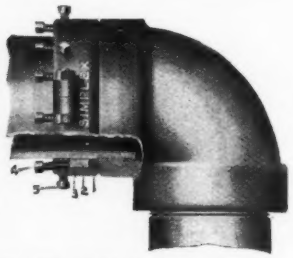
THE DAVIS PRESSURE REGULATOR operates on the principle of balancing the pressure by direct weight. This simple and effective arrangement insures a degree of sensitiveness that never fails. No troublesome packing, auxiliary valves, internal dash-pots or small ports to become clogged with scale.

If you want to reduce the steam from any initial pressure to any delivery pressure, and maintain it constantly, *you need the "Davis."* BOOKLET?

G. M. DAVIS REGULATOR CO.
142 MILWAUKEE AVE., CHICAGO, ILL.

BRANCHES:
New York—123 Liberty St. Boston—104 High St. St Louis—735 S. 4th St.
San Francisco—216 California St. Philadelphia—56 N. 2nd St.
Pittsburgh—1206 Park Building.

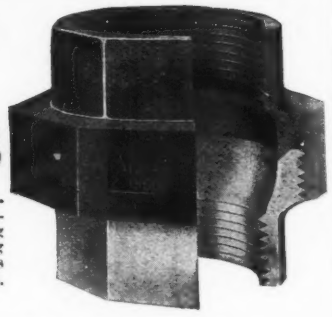
FIRST and FINAL AID TO LEAKY JOINTS



Don't let your plant bleed to death. The most leaky joints can be made absolutely and permanently tight by means of the Simplex Pipe Clamp. Any one can apply this device while the pipe is under full pressure. We'll send you one on a 30 days' trial. Write for Bulletin.

The Simplex Engineering Co.,
316 Preston Street, Philadelphia, Pa.

IRON *AGAINST* BRASS



That's the contact that prevents rusting and sticking. "Kewanee" Unions have everything in their favor. Self-seating ground ball joint. No gaskets required. Fewer joints needed. Write for full particulars.

National Tube Co., Pittsburg, Pa.
DISTRICT SALES OFFICES

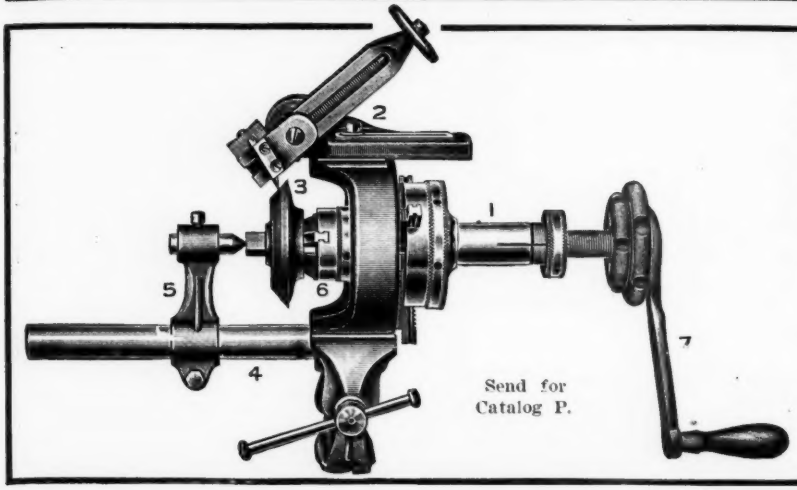
Atlanta	Denver	New York	Pittsburg	St. Louis	Salt Lake City
Chicago	New Orleans	Philadelphia	Portland	San Francisco	Seattle

The Only Wearing Part

of a **"P. B. H." Gauge Cock** is the valve pencil. It lasts a long time and can be renewed for a few cents when necessary.

We send the "P. B. H." on free trial. Thirty days in your plant will prove its value to you.

The Paul B. Huyette Co., Inc.
2025 Betz Building, Philadelphia.



Send for Catalog P.

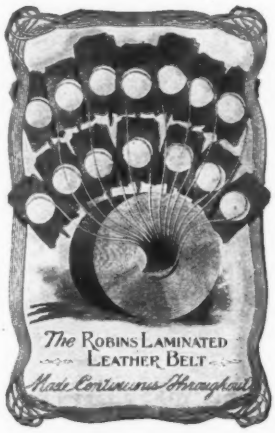
THE seat of a valve is often the cause of leaks. The constant passing of steam or water wears away the seat unevenly. You'll never have an absolutely tight valve unless the seat is true. A new disc can never make tight valves when the seat is not true.

Recut your valve seats and their discs with a

Dexter Valve Reseating Machine

and you'll always have tight valves.

The Leavitt Machine Company
Orange, Mass., U. S. A.



Practically Akin to a Positive Drive

ROBINS LAMINATED LEATHER BELTING

The only logical choice between direct connection and the belt.

Indispensable for High Speed Heavy Duty Service

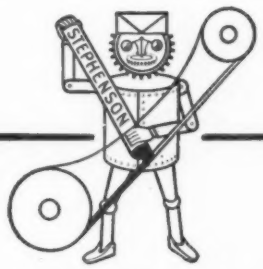
Made from continuous units cut in strands of full roll length from the finest selected oak tanned belting butts. The strands are cut to gauge and the width determines the thickness of the belt when they are laid on edge and laminated together. Every strand is stretched independently to the full elastic limit guaranteeing a belt which is practically *non-stretchable*. **NO LAPS, NO PLIES NO CEMENT**—joined endless upon the pulleys with a neat and simple splice which holds the gauge, balance and strength of the belt intact.

WRITE FOR CIRCULAR No. 2.

ROBINS NEW CONVEYOR COMPANY

Factory : 168 Duane St., New York.

New York : 38 Wall St. Chicago : Old Colony Bldg.



THE AFTER EFFECTS ARE PLEASANT

Don't waste good belts and lose valuable power. **STEPHENSON Bar Belt Dressings** contain no Rosin nor any other ingredients injurious to Belting. Our **RED Label** and **GREEN Label Brands** are two entirely different and distinct preparations. No **one** kind of Dressing is good for **all** Belts—you know that. **STEPHENSON Dressing** not only prevents slipping and gives full speed from slack belts, but **the after effects are pleasant**—it KEEPS those belts in good condition and greatly prolongs their life.

This means a saving in BELTING, which is an important item when figuring the year's expenses.

RED Label Brand for Leather belts;

GREEN Label for Rubber and Canvas.

Your protection against substitution is **The Man with the Cog-Wheel Face** on each Pound Stick.

Of Dealers everywhere, or

STEPHENSON MFG. CO.

ALBANY, N. Y

RHOADS LEATHER BELTING

Handsome is as handsome does.

J. E. Rhoads & Sons

PHILADELPHIA 12 N. THIRD ST. BOSTON NEW YORK 40 FULTON ST.

HAMBLET & HAYES CO. EASTERN AGENTS, 105-111 SUMMER ST.

FACTORY WILMINGTON, DEL.

SAGINAW MANUFACTURING CO.,

SAGINAW, MICH., U. S. A.

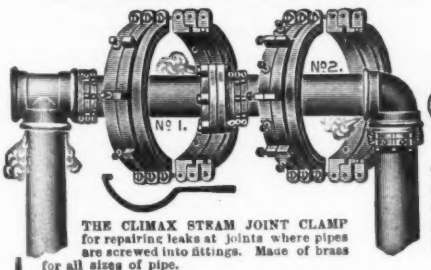
MANUFACTURERS OF

GILBERT WOOD SPLIT PULLEYS.

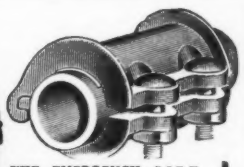
New York Branch, 88 Warren Street.
Chicago Branch, 32 South Canal Street.
Sales Agencies in all principal cities.
Cable Address, "Engrave" A. B. C. and Lieber's Code.

Belting Logic—If best Leather Belting costs per sq. ft. $1.00, best Rubber Belting 60c, and best Stitched Canvas Belting 40c., and with Leather showing 25% and Rubber 50% of the strength of **Best Stitched Canvas Belting,** wouldn't it be good policy for you as a practical man to investigate the merits of our product? Send for Book "C."

SAWYER BELTING COMPANY, **CLEVELAND, OHIO.**



THE CLIMAX STEAM JOINT CLAMP for repairing leaks at joints where pipes are screwed into fittings. Made of brass for all sizes of pipe.



THE EMERGENCY PIPE CLAMP, for repairing splits and rust holes. Made of malleable iron from ⅛ in. to 12 inches.

PIPE REPAIRS FOR ANY CONDITION

Send for Catalog of

STEAM SPECIALTIES

JAMES McCREA & CO.,

MANUFACTURERS,

61 West Washington Street, Chicago.

A LIVE BELT.

Get a Belt with life in it. An oak-tanned belt is invariably tanned until dead all through, and after running on the pulleys a short time, becomes hard, brash and stiff.

SHULTZ SABLE BELTING is stronger and more pliable than any other leather belting, because it retains the original qualities of the rawhide.

A **SHULTZ SABLE BELT** will transmit from 25% to 33% more power than oak-tanned belting and will last much longer.

Send for our Belt Book "No. 4."
Get a Shultz Sable Belt for 30 days' free trial.

SHULTZ BELTING CO.,

ST. LOUIS, MO.

New York Boston Philadelphia

LATEST IMPROVED

ROCHESTER

AUTOMATIC LUBRICATORS

give perfect force feed lubrication and *save oil, time, money* and *labor.*
Try one, or at least, send for a catalog.

GREENE, TWEED & CO., SOLE MANUFACTURERS, 109 Duane St., NEW YORK.

ACCIDENTS IMPOSSIBLE

where the Akron Friction Clutch is found because it is *smooth* and *round* with no extended parts. Its action is smooth too—no chattering. 'Tis easily applied to the shaft and starts the load gradually without shock or jar. 'Twill *slip* if load exceeds its horsepower. Write for Booklet.

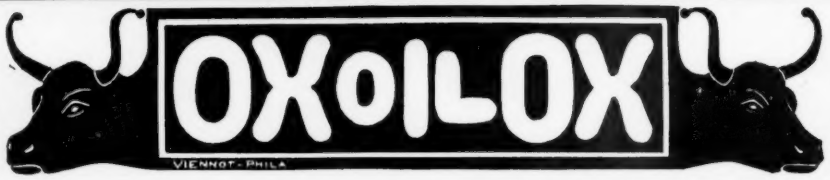
The Williams Foundry & Machine Co.,
Successors to the Akron Clutch Co. Akron, Ohio.

GRAPHLIO MAKES YOUR OIL GO TWICE AS FAR

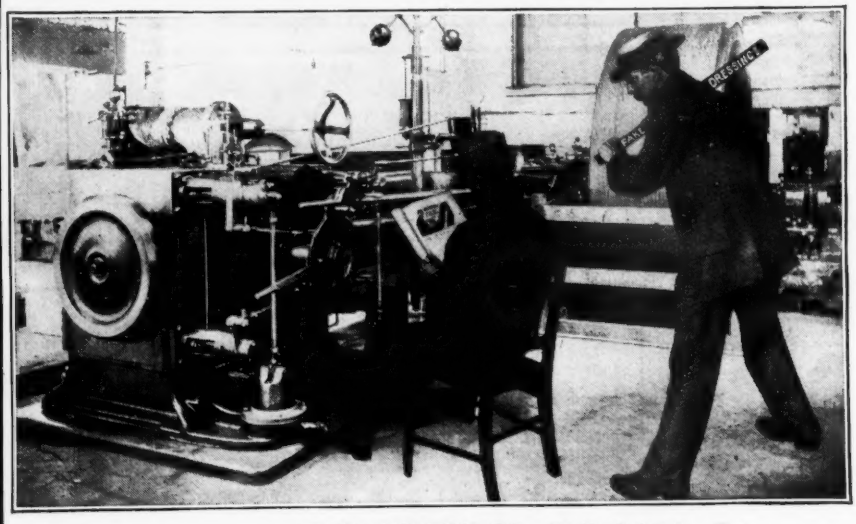
It is a pure Crystalline Graphite—an impalpable powder, free from grit or dirt. Mixed with any lubricating oil (in the proportion of about 1 to 200) **it remains in suspension** and doubles the efficiency of the oil.

It costs about 5 cents per gallon to graphitize your oil with "Graphlio," and the oil can be used in your regular oiling systems. *Write.*

WALTER D. CARPENTER & CO.,
39 CORTLANDT STREET, NEW YORK.



DON'T BE SAND-BAGGED



DON'T let some slick tongued fellow make you pay for ruining your own belts. **You know** that resin does your belts no good; you know that tallow and lard are not worth much for belt dressings; don't buy them then just because they are put up in an attractive package and labelled "Belt Dressing."

Get acquainted with **OXoilOX,** pure Neatsfoot Oil refined and improved so that it preserves and strengthens belts.

OXoilOX doesn't make belts sticky. It isn't a dope—it's a belt food, that keeps belts **soft** and **tough** and **clean.** Belts treated with **OXoilOX** cling to pulleys so closely that air is absolutely excluded, and the vacuum thus formed prevents slipping, and enables belts to **run slack** at full load.

Our booklet tells how **OXoilOX** was discovered—you'll be interested; mailed free on request.

A FREE SAMPLE

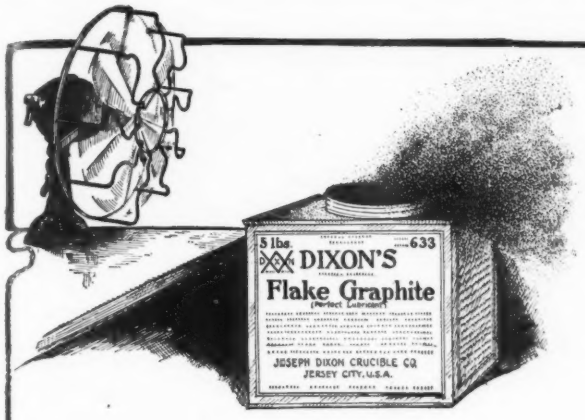
F. S. WALTON CO., Philadelphia, Pa.

Gentlemen: Kindly send us, free of charge, a sample can of OXoilOX the Perfect Belt Dressing.

Name.....Address.....

Name of Firm.....Number of Belts.....Average Size.....

F. S. WALTON CO., Philadelphia, Pa.
Pressers and Refiners of all grades of Neatsfoot oil.



The First Aid to The Oil Can is DIXON'S FLAKE GRAPHITE

Neither grease nor oil alone can keep friction at an economical minimum. But mix with either a little pure flake graphite (the Dixon kind), and you'll get the smoothest possible surfaces and a practical annihilation of friction.

This means longer life for the bearings, a big saving in power and a general efficiency increase.

WRITE TODAY FOR FREE SAMPLE CAN NO. 94-C.

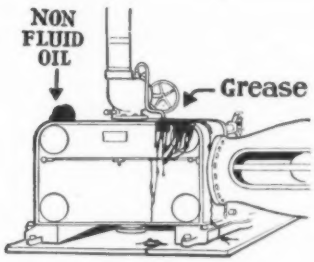
JOSEPH DIXON CRUCIBLE COMPANY

JERSEY CITY, N. J.

TRADE MARK REGISTERED IN UNITED STATES PATENT OFFICE

NON-FLUID OILS

Get a Free Sample of Non-Fluid Oils and MAKE THIS TEST



Just to prove that NON-FLUID OIL does NOT thin out (remains firm and clean in the hottest weather,) while grease does, put equal portions of each on the steam chest of your engine.

You can then see why NON-FLUID OIL lubricates effectively under conditions where 85% of the same bulk of grease would have wasted without doing any work.

NON-FLUID OIL is as decided an improvement over grease and oil as is modern machinery over the types used years ago. Let us convince you of this at our expense.

Samples without charge and by paid express.

Originators and Sole Manufacturers.

N. Y. & N. J. LUBRICANT CO.

DEPT. A.

14-16 CHURCH ST., NEW YORK.

N. Y. & N. J. LUBRICANT CO.,
Dept. A., 14-16 Church Street,
New York City.

Please send free sample of NON-FLUID OIL for the following engine

(State kind and H. P. of engine)

State on what part sample is to be used

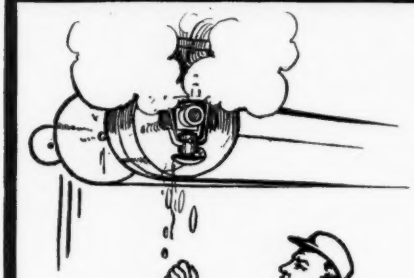
NAME .....

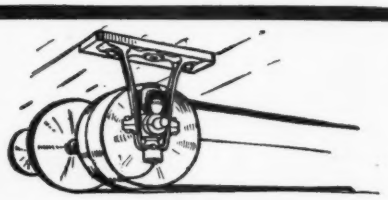
ADDRESS.....

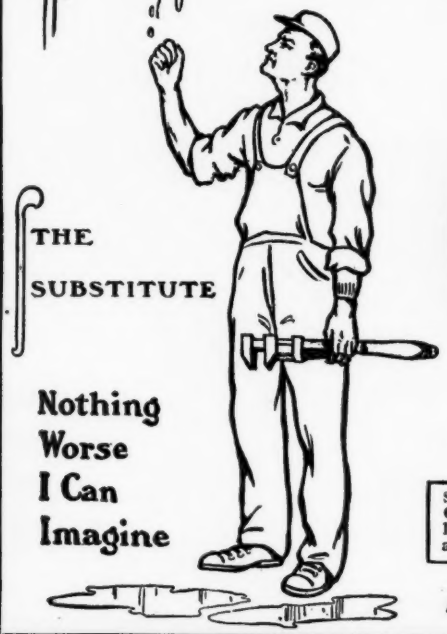
No 11

THERE IS ONLY ONE

ALBANY GREASE







THE SUBSTITUTE

Nothing Worse I Can Imagine

The only Genuine ALBANY GREASE has this trade mark on every package. Look and ask for it.

Send for FREE sample cup and can of "Albany Grease," giving size of tap for cup, depth of oil hole from top of cap to journal, where to be used and firm's name.

MADE ONLY BY
ADAM COOK'S SONS,
313 WEST ST., NEW YORK.

NOTHING EASIER I SEE

THE ONLY GENUINE

Detroit Improved Standard Lubricator

Some One

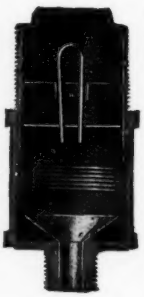
of our 337 different styles and sizes of sight-feed lubricators will fill any requirement you may have.

When ordering, insist on getting the genuine Detroit.

Write for a catalog of the most complete line of oiling devices for all purposes.

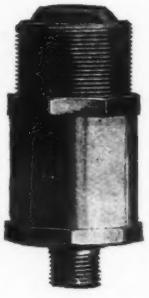
DETROIT LUBRICATOR COMPANY.
Detroit, U. S. A.

The "Philadelphia" Grease Cup



Automatic application of grease to the bearing without the use of spring compression. : : : :

Nature Supplies the Feeding Force in the Form of Compressed Air. : : : : : :

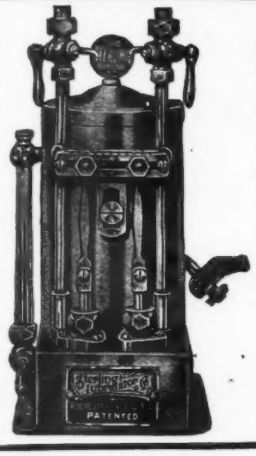


With many thousands of the "Philadelphia" Grease Cups in successful operation, on machinery of almost every description, we offer a system of lubrication which, for simplicity, cleanliness, economy, reliability and efficiency has no equal.

The "Philadelphia" Cup is not merely "as good as any other:" IT IS THE BEST, and we are prepared to prove our claim for actual superiority. There are more reasons for its practical success than we have room to mention here.

Write for catalogue and full information

The Philadelphia Lubricator & Manufacturing Co.
The Bourse (Exhibition Dept.), Philadelphia, Pa.



Salvation

of oil means a big economy in any power plant, provided the machinery at the same time receives perfect lubrication. Both those ends are gained most satisfactorily by the *Sterling Force Feed Lubricator*. Prove it by a 30-days' free trial.

Catalog?

STERLING LUBRICATOR CO.
3 Frank St., Rochester, N. Y.

PYRAMID BOILER COMPOUND is positively guaranteed to remove and prevent boiler scale. Let us show you how and why. *Write.*

Binghamton Boiler Compound Co.
BINGHAMTON, NEW YORK.
Los Angeles, Cal.; Seattle, Wash.; Portland, Oregon; Cincinnati, Ohio; Cleveland, Ohio; Providence, R. I.; Syracuse, N. Y.; Scranton, Pa.; Louisville, Ky.; St. Louis, Mo.; Birmingham, Ala.

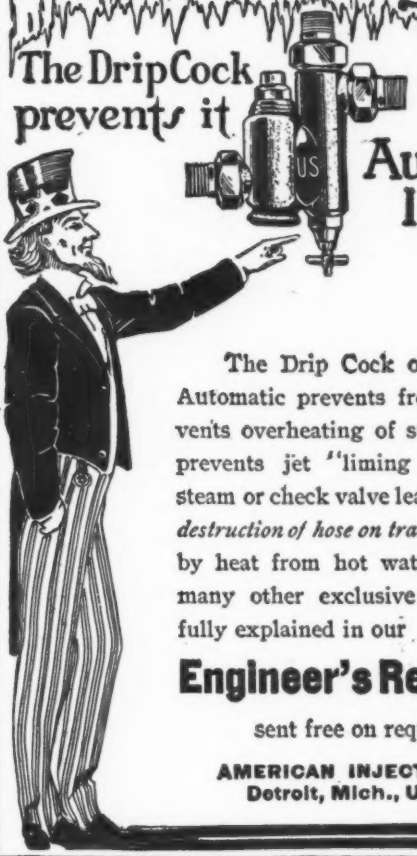
THE HAWK-EYE BOILER COMPOUND NEVER FAILED.

See our Advertisement in First Issue Every Month.

HAWK-EYE COMPOUND CO.,
303-304-305 Merrick Block, CHICAGO, ILL.

No Freezing Here

The Drip Cock prevents it



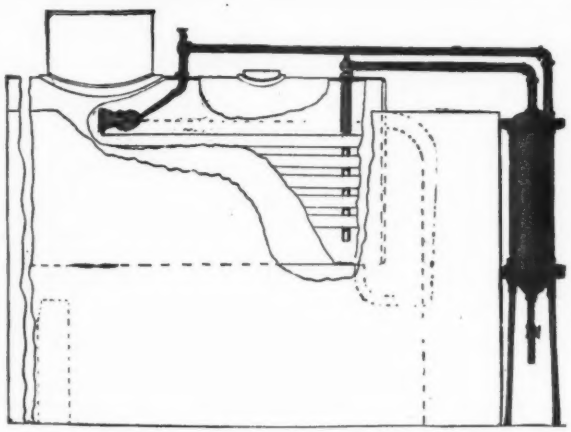
U.S. Automatic Injector

The Drip Cock of the U. S. Automatic prevents freezing; prevents overheating of suction pipe; prevents jet "liming up" when steam or check valve leaks; *prevents destruction of hose on traction engines* by heat from hot water, and has many other exclusive advantages fully explained in our

Engineer's Red Book

sent free on request.

AMERICAN INJECTOR CO.
Detroit, Mich., U. S. A.



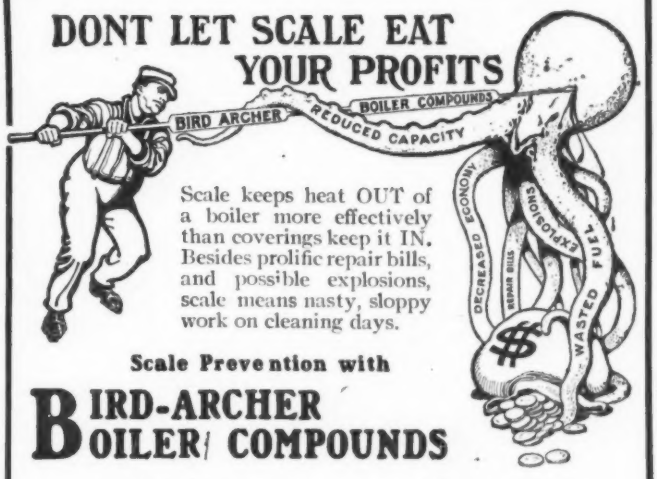
One user of the

BUCKEYE BOILER SKIMMER

writes that after operating a boiler 16 hours per day for 30 days with a Buckeye, it was found to contain only one quart of mud. The same boiler without the skimmer had been cleaned every 10 days and each time had contained many quarts of mud. Write for full details.

The Buckeye Boiler Skimmer Co.,
South End, Toledo, Ohio.

DONT LET SCALE EAT YOUR PROFITS



Scale keeps heat OUT of a boiler more effectively than coverings keep it IN. Besides prolific repair bills, and possible explosions, scale means nasty, sloppy work on cleaning days.

Scale Prevention with

BIRD-ARCHER BOILER COMPOUNDS

at much lower cost and no delays is far more profitable than scale removal at $50.00 or so per boiler and several weeks' shut down per year, to say nothing of wasted coal while scale is collecting.

If Bird-Archer Compound doesn't keep your boilers in better shape than any other scale remedy, it won't cost you a cent.

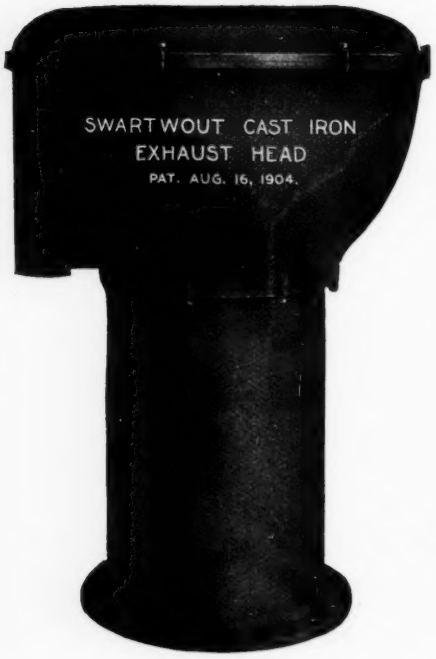
Try it for six months on this "NO CURE, NO PAY" basis.

WRITE FOR PRICES

BIRD-ARCHER COMPANY
90 WEST ST., NEW YORK

10

"WHAT WILL IT DO"?



NOT "What will it cost"? is the first question asked by the far sighted purchaser. The **"Swartwout" Cast Iron Exhaust Head** is not cheap in the sense of first cost. But efficient service year after year without attention makes it the cheapest in the end. It absolutely separates water and oil from the steam, it produces no back pressure, it won't wear out nor rust out.

THE OHIO BLOWER CO.,
CLEVELAND, OHIO.

Also manufacturers of "Swartwout" Gravity-Closing Ventilators.

1-60

Carey's 85 per cent Carbonate Magnesia Coverings

THE largest contract ever awarded for steam pipe and boiler coverings specified Carey's. This was the result of an exhaustive test conducted by the Manhattan Railway Company of New York, which proved Carey's Coverings to be more efficient and far superior in every way to any other of the numerous makes. No other coverings proved to be as light, clean and substantial.

Carey's Coverings are absolutely fire-proof, and being thorough non-conductors of heat they confine the heat to the pipes, effectually preventing its loss through radiation, thus saving in fuel an amount sufficient to *more* than offset the cost of their application.

The most prominent steam users everywhere use Carey's Covering. Do you want to know why?

Send for Carey's Magnesia Catalogue. It gives information not obtainable elsewhere.

THE PHILIP CAREY COMPANY

General Offices: Station R, Cincinnati, O.

FACTORIES: Lockland, Ohio; Plymouth Meeting, Pa.

Branches and Warerooms:

New York: 114-118 Liberty Street.
St. Louis: 908 North 2nd Street.
Baltimore, Md: 332-334 North Street.
Philadelphia, Pa.: 12th and Buttonwood Sts.
Toronto, Canada: 112 Bay Street, East.
Cleveland, Ohio: 123 Water Street.
Buffalo, N. Y.: 45 Pearl Street.
Pittsburg, Pa.: 333-335 Second Avenue.
Atlanta, Ga: 34 West Alabama Street.
Charlotte, N. C.: East 7th and R. R. Streets.
New Orleans, La.: 222 Chartres Street.

PROTECT YOUR ROOF

WITH A

HOPPES

CAST IRON

EXHAUST HEAD

A FEW POINTS NOT TO BE OVERLOOKED:

Symmetrical in design—neat in appearance—will not rust out—*guaranteed* to thoroughly entrap the water and oil from the exhaust without any back pressure—prices right.

THE HOPPES MFG. CO.

Manufacturers also of EXHAUST STEAM FEED-WATER HEATERS, LIVE STEAM FEED WATER PURIFIERS, STEAM SEPARATORS, OIL ELIMINATORS.

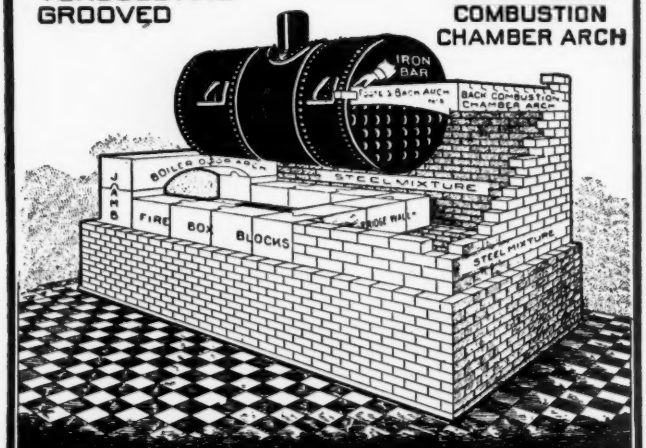
19 Larch Street, Springfield, Ohio.

"STEEL MIXTURE"

BOILER DOOR ARCHES AND FIRE BOX BLOCKS

TONGUED AND GROOVED

PATENT BACK COMBUSTION CHAMBER ARCH



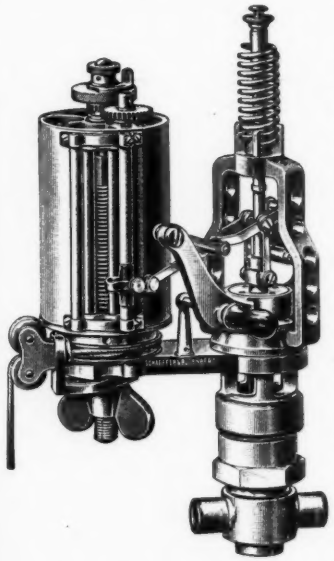
MANUFACTURED BY

McLEOD & HENRY CO.

TROY, N.Y., U.S.A.

BRANCH OFFICE, 1402 BROADWAY, NEW YORK CITY.

IDEAL FOR STEAM OR GAS ENGINES



The Thompson Improved Continuous Card Indicator enables you not only to know the condition at the instant of reading, but also to take the record over a long enough time to secure *reliable information.*

From 50 to 100 indications can be taken without removing the paper. The outside spring enables quick changes to be made. The Indicator takes a strip of paper 6 feet long. Write for catalog describing other superior features.

Schaeffer & Budenberg Mfg. Co.

Main Office and Works:

963-965 KENT AVE., BROOKLYN, N. Y.

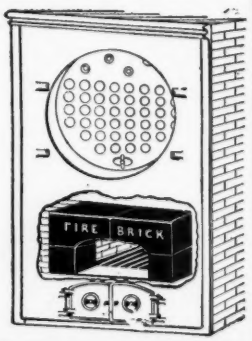
Western Salesroom: 15 W. Lake Street, Chicago.

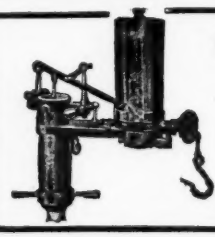
HEAT PROOF

The heat resistance of our fire brick is wonderful. We fit every type of boiler setting.

Write for catalog and prices.

Presbrey Fire Brick Works, Taunton, Mass.





BETTER THAN THE REST AND FOR $50 LESS

than will buy any other first class indicator. Write for one on free trial.

THE TRILL INDICATOR COMPANY

Eagle Street CORRY, PA.

PREVENT SMOKE

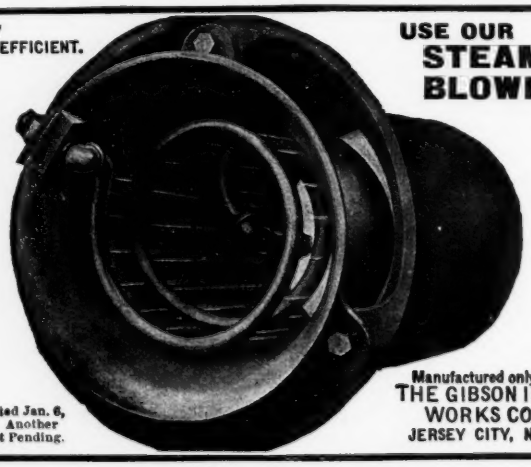
Write to us for descriptive matter relating to a device that is mechanically correct, simple in construction, absolutely automatic, and its effectiveness in preventing smoke from Bituminous coal under any and all conditions has been fully demonstrated.

CLIMAX SMOKE PREVENTER COMPANY

205 Equitable Building, Boston, Mass.

VERY EFFICIENT.

USE OUR **STEAM BLOWER**



Patented Jan. 6, 1903. Another Patent Pending.

Manufactured only by THE GIBSON IRON WORKS CO., JERSEY CITY, N. J.

"SIROCCO"

TRADE MARK

FANS AND BLOWERS

BUILT ON THE TURBINE PRINCIPLE

SIROCCO ENGINEERING CO., 138 Cedar Street, New York

CHIMNEYS

WIEDERHOLDT CONSTRUCTION CO.

American Trust Bldg., Chicago, Ill.

SAVE THE SMOKE STACK!

Expensive steel smoke stacks can be saved from destruction by the gases of combustion, acid fumes and dampness at a small cost by lining them with VITRIBESTOS SMOKE STACK LINING.

VITRIBESTOS is the only absolutely fire and waterproof insulation for lining smoke stacks that is also proof against acid fumes and gases of combustion. Sulphurous or other gases of combustion, fire or water have no effect whatever on it.

Sectional view of lining, showing angles, lugs and bolts.

Vitribestos Smoke Stack Lining

has many advantages over brick for this purpose. VITRIBESTOS 2 inches thick will accomplish better results than brick 5 inches thick, and save 15 per cent of flue space. Weighing but one-tenth as much, a lighter foundation can be used. As the weight of the lining must be supported by the steel, it results in a large saving of steel, by allowing reduction in diameter and thickness. It can be sawed, drilled, cemented, split and handled like wood. And, with all these advantages over brick, VITRIBESTOS costs but half as much.

Sectional view, showing face of lugs, bolts and angles for Vitribestos Lining for smoke stacks.

Write nearest branch for Vitribestos Catalog No. 108.

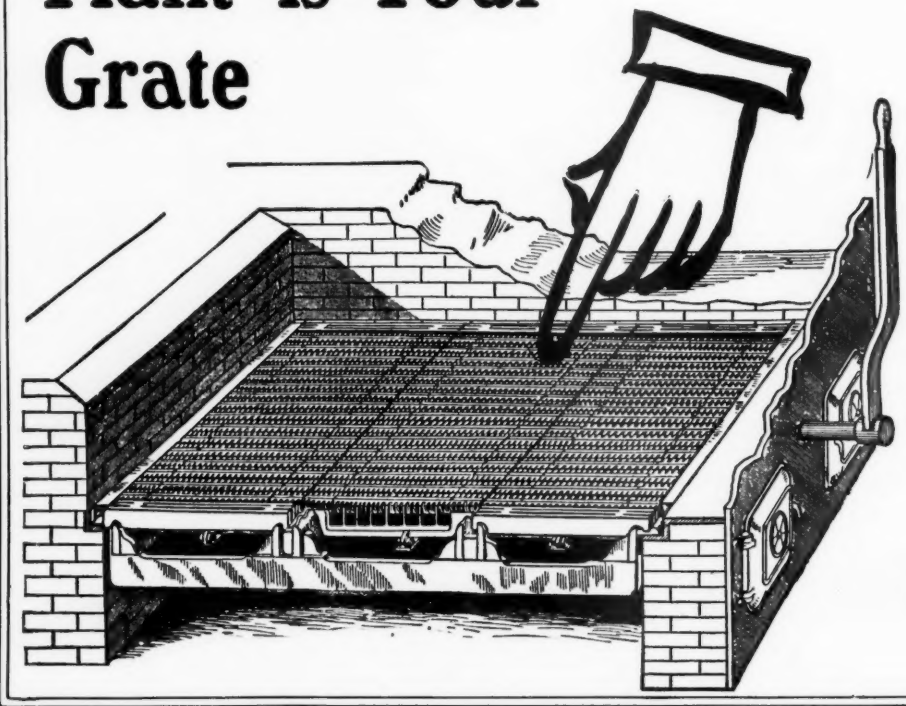
H. W. JOHNS-MANVILLE CO.

Manufacturers of Asbestos and Magnesia Products, Asbestos Roofings, Packings, Electrical Supplies, etc.

New York	St. Louis	Baltimore	Los Angeles
Milwaukee	Pittsburg	New Orleans	Seattle
Chicago	Cleveland	Kansas City	Dallas
Boston	Buffalo	Minneapolis	Toronto
Philadelphia	Detroit	San Francisco	London

732

The Heart Of Your Plant is Your Grate



STOP your fire and your plant is idle. Burn your fuel poorly and the efficiency of your plant shows a marked falling off. Buy *cheap fuel* and burn it *ALL*, and you'll save money, besides getting every bit of good out of each machine.

The Martin Anti-Friction Rocking Grate guarantees this latter condition. It can be installed in any furnace without altering the fire-box.

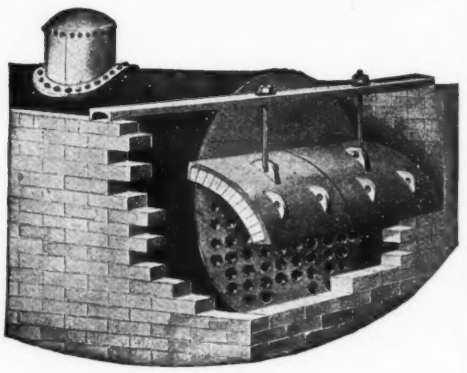
Write for full description.

The Martin Grate Co.
281 Dearborn St.
Chicago, Ill.

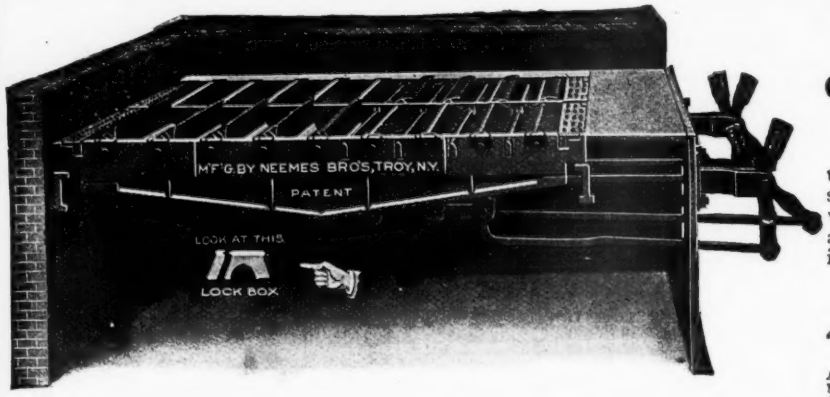
FREEDOM FROM BROKEN DOWN ARCHES

comes through using the **Monarch Boiler Arch.** It hangs from above in such a manner that there's plenty of room allowed for expansion. Permits easy access to boiler.

Sold subject to trial and approval. Money refunded if not satisfied. Booklet ?



MAYVILLE SPECIALTY MFG. COMPANY
General Founders and Machinists
MAYVILLE, WIS.



NEEMES BROS.

IMPROVED

Clinker Cutting, Shaking and Dumping Grate

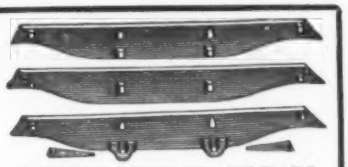
unlike all other grates will cut from both sides of the shaker alike. Makes more steam with cheaper fuel and less of it. A slight agitation shakes out the ashes or a full opening dumps everything into the ashpit. *Write.*

NEEMES BROS.,
41-49 Adams St., TROY, NEW YORK

C. W. VAN BLARCOM, Room 533, Terminal Bldg., 30 Church St., Agent for New York City and vicinity BABCOCK & WILCOX, Ltd., Montreal, Canada, Sole makers for Canada BURKE ENGINEERING CO., 511 Industrial Bldg., Providence, R. I., Sole Agents for the New England States.

Everything Depends On The Grate

for it is the source of power. This grate is used in more than 10,000 furnaces. Get our grate book.



INTERLOCKING GRATE BARS.

SALAMANDER GRATE BAR CO. Telephone, 4136 Cortlandt. **126 LIBERTY ST., NEW YORK**

CONTRACTORS.
CENTRAL STATION HEATING.

Write for valuable information.

AMERICAN DISTRICT STEAM CO.,
Lockport, N. Y. Toronto, Can. Chicago.

Ideal Steaming Conditions

without tall chimneys and with a great reduction in cost of fuel results from the use of Wing's Turbine Blowers. Write for particulars.

L. J. Wing Mfg. Co., 90 West St., New York.

ANY TYPE OF BOILER

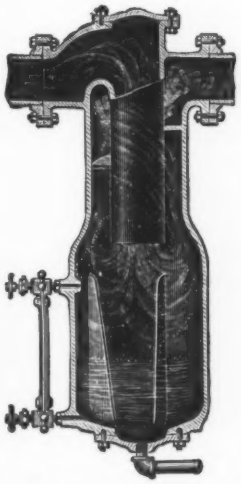
The Murphy Automatic Smokeless Furnace

burns slack and other low cost fuels with unexcelled economy and absolute smokelessness. Strictly automatic in feeding and distribution of coal and the removal of the ash. Send for a complete description.

MURPHY IRON WORKS, 5 Walker St., DETROIT, MICH.
UNITS OF ANY SIZE

Forcing The Boilers

Won't Increase the Power of Your Engine



if wet steam goes into the cylinder. It must reach the engine

ABSOLUTELY DRY

in order to make the forced firing profitable. And in order to get dry steam you must have a

STRATTON SEPARATOR.

It is the only apparatus that is *absolutely infallible* under these conditions.

CATALOG WILL TELL WHY.

GOUBERT MANUFACTURING CO.,
No. 90 West Street. New York City, N. Y.

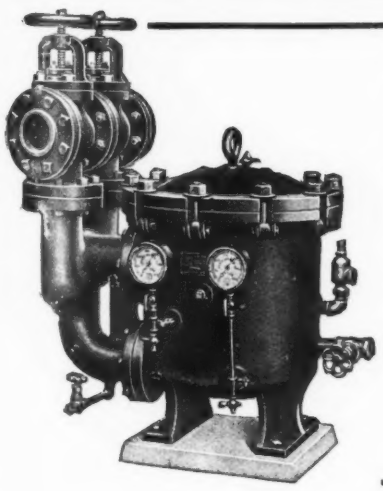
C-O-Two Furnace Tile

The best fire arch making material ever devised. Lasts longer. Increases combustion. Write for full description.

C-O-Two Furnace Co., Syracuse, N. Y.

GREEN TRAVELING CHAIN GRATES
AUTOMATIC SELF CLEANING SMOKELESS
GREEN ENGINEERING CO.
COMMERCIAL NATIONAL BANK BLDG., CHICAGO;
GENERAL FOUNDY WORK A SPECIALTY

Over 7500 Hammel Oil Burners
In use under Stationary Boilers, Locomotives, Kilns, Etc.
Write for Circular of Hammel Patent Furnace for Water-Tube Boilers
HAMMEL OIL BURNER CO.
609 North Main Street. LOS ANGELES, CAL.



Does Oil Get Into Your Boilers?

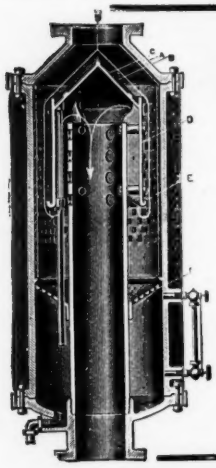
If it does, remember that the most serious boiler troubles result directly from this cause.

The Blackburn-Smith Feed Water Filter and Grease Extractor

will save much money that you spend on these repairs, and will increase fuel economy by keeping objectionable matter out of the boiler. Our system of DOUBLE FILTRATION through separated Terry Cloths does the trick, by catching the floating particles just before they reach the boiler. Write for booklet, "Feed Water Filtration."

James Beggs & Co.

106 Liberty Street, New York



SWEETS

Steam Separators deliver 99.8 dry steam and oil separators remove 99% of oil from exhaust steam. They *do* it that's all. All styles.

DIRECT SEPARATOR COMPANY,

712 S. Geddes St., Syracuse, N. Y.

All Working Parts Hard Brass

and rendered easily accessible by being externally located. The

Morehead Non-Return Steam Trap

has no gaskets to blow out or leak, no ball or globe floats to collapse, leak, rust or stick. The use of buckets, pans, springs and other troublesome features is studiously avoided.

WRITE TODAY.

MOREHEAD MANUFACTURING CO.,

1051 GRAND RIVER AVE., DETROIT, MICH.

We Don't Want You To Risk A Penny

We know that Baum Separators will prove a highly profitable investment and we are ready to prove it at our own expense. The Baum removes every bit of grit, oil and condensation water from your steam.

Send for new Catalogue and prices.

HERSHEY MACHINE & FOUNDRY CO.

MANHEIM, PA., U. S. A.

W. G. Ruggles Co., 54 High St., Boston, Mass.
R. D. Bliss, 40 Dearborn St., Chicago, Ill.

A FAIR TRIAL

is all we ask for the GEIPEL STEAM TRAP

Will You Try One?

CIRCULARS FOR THE ASKING

JOHN PLATT & COMPANY,

97 CEDAR STREET, NEW YORK.

Is Your Engine Getting Dry Steam?

WHAT assurance have you that the cylinders of your engine are immune against the dangerous slugs of water that are carried over into the engine due to foaming boilers or long steam mains where there is considerable condensation?

Water in an engine cylinder cuts the valves, scores the cylinders, interferes with lubrication and there is a constant danger of the cylinder head blowing out. Why not avoid the issue by using a

COOKSON STEAM SEPARATOR

on the throttle of your engine. It will not only safeguard your plant against accidents, but increase the efficiency of your engine by maintaining a constant supply of *dry* steam at the throttle without any decrease from initial pressure. Of simple and compact construction, it appeals to the man who has an eye for practical economy.

Write for descriptive catalog.

THE D. T. WILLIAMS VALVE CO.

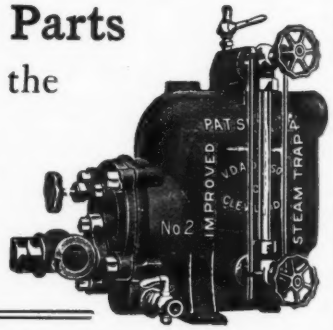
904-910 Broadway, - CINCINNATI, OHIO

8

All Working Parts

are attached to the Head and can be exposed by its removal.

WRITE.



THE V. D. ANDERSON CO.

1935 West 96th Street, CLEVELAND, OHIO

Wet Steam Makes Lubrication Difficult

prevents equal distribution of steam and rapidly cuts out valves and pistons.

The **Gardner Separator** removes the water more completely and reduces operating cost to a lower figure than any other device for this purpose.

WRITE!

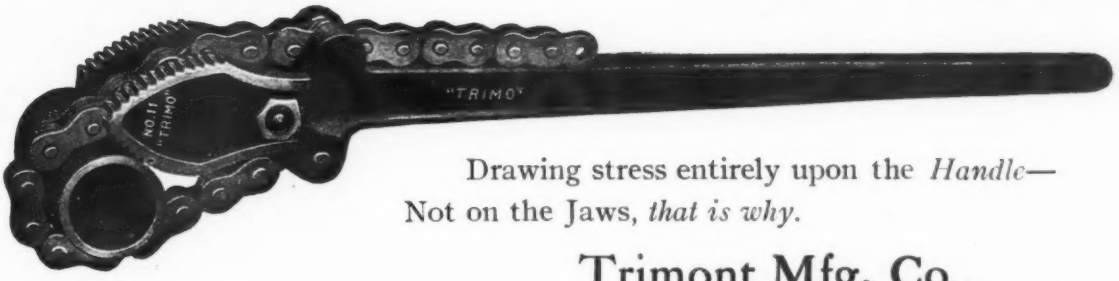
The Gardner Governor & Separator Company,

Quincy, Illinois.

"Trimo"

Strongest of All Chain Wrenches

Gold Medal St. Louis, 1904

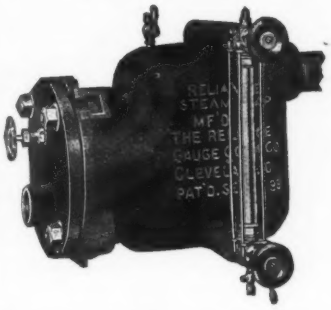


Drawing stress entirely upon the *Handle*—
Not on the Jaws, *that is why.*

Sent free
New Catalogue No. 21. *Write for one.*

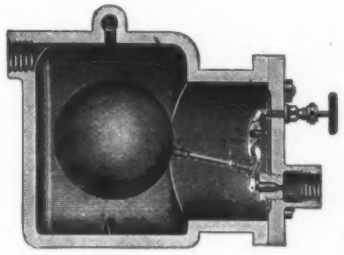
Trimont Mfg. Co.,
55-71 Amory St., Roxbury, Mass., U. S. A.

No Matter How Fast Or How Slow It Comes



The Reliance Steam Trap takes all the water that comes, discharges it without loss of steam and works without watching.

WRITE.



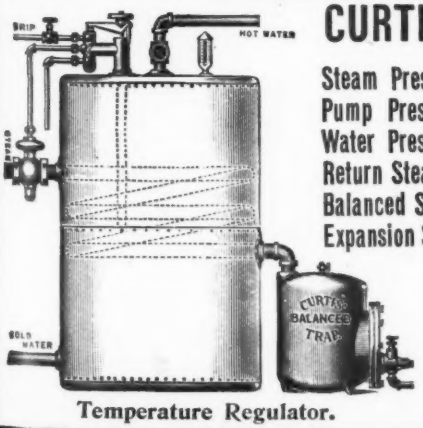
THE RELIANCE GAUGE COLUMN CO., 75 East Prospect St., Cleveland, O.

Steam Traps
Reducing Valves
Safety Water Columns
Low Water Alarms
Low Pressure Boiler Feeders

THERE ISN'T A POWER PLANT THAT COULDN'T BE BETTERED BY KITTS SPECIALTIES.

KITTS MFG. COMPANY,
OSWEGO, N. Y.

Pump Governors
Fan Engine Regulators
Damper Regulators
Safety Feed Water Regulators
Vacuum Pressure Reducing Valves



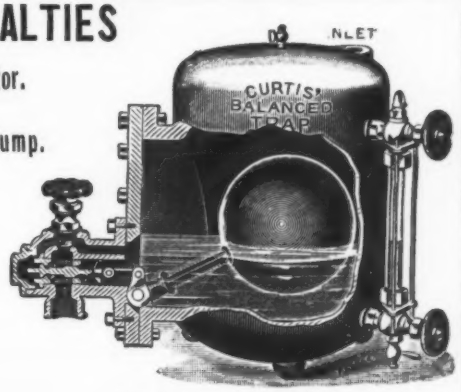
Temperature Regulator.

CURTIS ENGINEERING SPECIALTIES

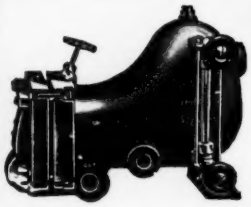
Steam Pressure Regulator.	Temperature Regulator.
Pump Pressure Regulator.	Damper Regulator.
Water Pressure Regulator.	Tank Governor and Pump.
Return Steam Trap.	Cellar Drainer.
Balanced Steam Trap.	Ballcock.
Expansion Steam Trap.	Separator.

Send for catalog.

MANUFACTURED BY
Julian d'Este Company,
24 Canal St., Boston, Mass.



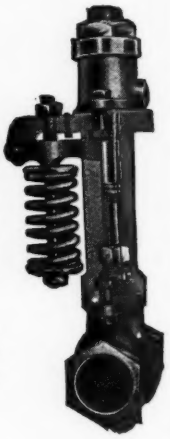
Balanced Steam Trap.



McDANIEL STEAM TRAPS

are especially adapted for draining steam separators and high pressure mains. Also good for steam heating. All working parts are attached to the bonnet, and are removable with it. Valve outlets are large, to give rapid discharges of condensation.

Watson Steam Pump Governor



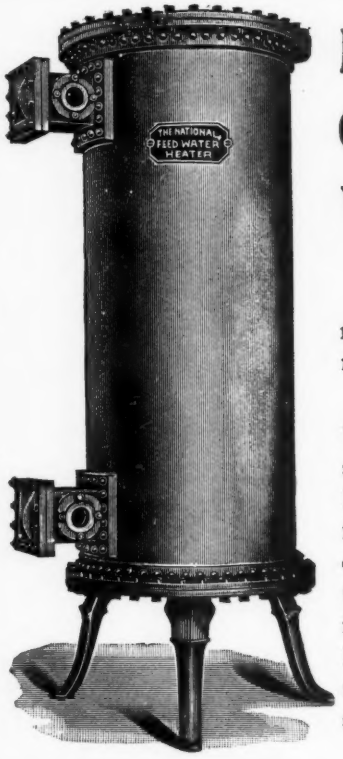
should be used on all steam pumps where a fixed discharge pressure is desired.

The construction permits of easy access to the stuffing box for removing packing, and the spring can be adjusted or entirely removed without interfering with any other part of the valve. Any practical man will readily see its advantages.

All our goods are made in our own factory and tested before shipping. We guarantee them to give perfect satisfaction. Established 1878.

Send for Catalogue.

Watson & McDaniel Co.,
148 North 7th Street, Philadelphia, Pa.



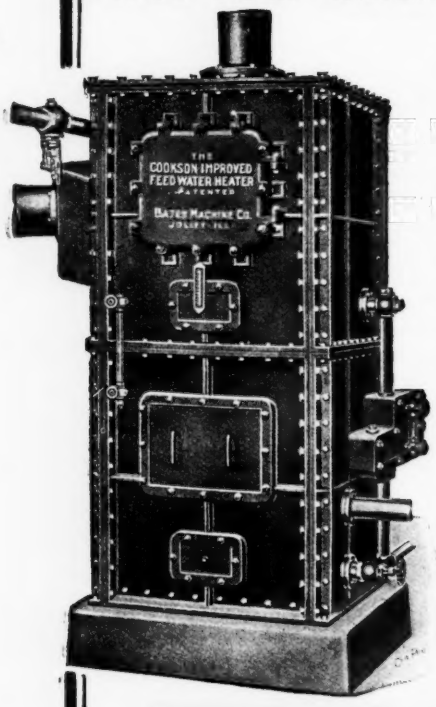
No Contact Of Water With Shell

Thus the shell neither corrodes, leaks, nor wears out.

The National Feed Water Heater is the simplest heater made. It has none of the faults common to ordinary heaters. We thoroughly guarantee it. Nearly a million H. P. in daily active use. Write for descriptive catalog.

The National Pipe Bending Co.,
175 Lloyd St., New Haven, Conn.
120 Liberty Street, New York.
54 High Street, Boston, Mass.

COOKSON STANDARD ALL CAST IRON FEED WATER HEATERS



Highest Temperature and Positive Purification of feed water.

Perfect Separation and Removal of Oil.

Automatic Control of Cold Water Supply.

Dry Steam for Heating Purposes.

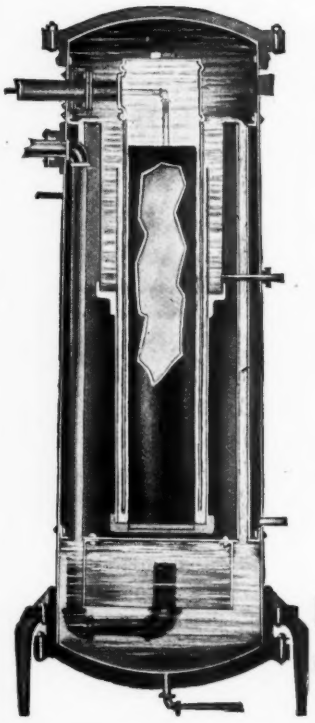
Finest Grade Special Fittings.

Lime Catching Pans. Especially Adapted for use with Heating Systems, Dryers, Etc.

Write for our new Heater Catalog.

BATES MACHINE COMPANY
Sole Manufacturers **Joliet, Illinois**

Better to Keep Scale Out Than to Take It Out

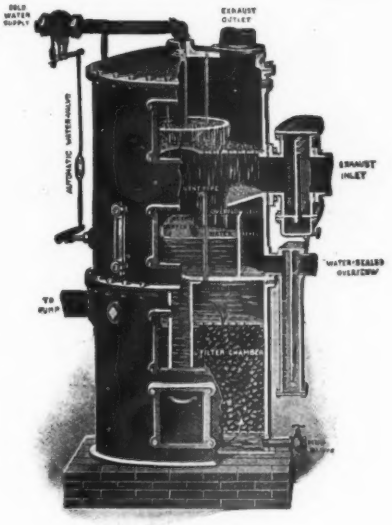


and it is as a keeper-out-of-scale that the Eclipse Feed-Water Heater and Purifier stands far in advance of all other devices or methods.

Ask for the book.

The Eclipse Feed-Water Heater & Purifier Co.
OSHKOSH, WISCONSIN

THE WHITLOCK OPEN EXHAUST
Feed Water Heater and Purifier

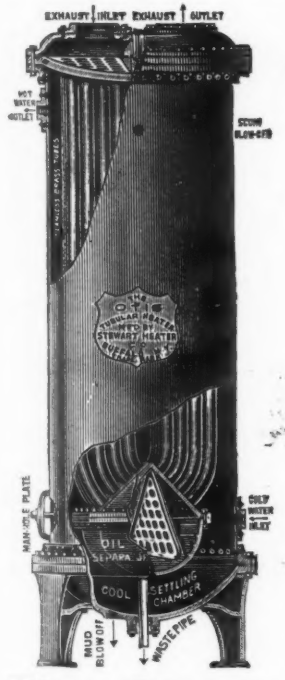


Perfect Oil Separation. Easily Cleaned. The Highest Possible Temperature in the Feed Water.

Manufactured by

THE WHITLOCK COIL PIPE COMPANY
HARTFORD, CONN.
New York Office—Singer Building, 85 Liberty Street.

The Otis Feed Water Heater and Purifier



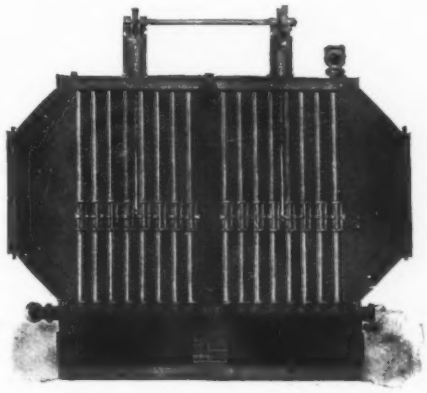
¶ The most easily cleaned.

¶ To heat feed water to 210° with out back pressure.

¶ To remove scale forming impurities.

¶ To save 15 to 25% over an injector.

The Stewart Heater Co.
45 E. Delavan Avenue, Buffalo, N. Y.



CAPACITY AND ECONOMY OF BOILERS USING OIL FUEL

Valuable Data Obtained by the U. S. Naval Board.

An advantage of oil fuel is that it admits of a great increase in steaming capacity. The boiler may easily be forced to the point of priming, while with coal as fuel the limit is set as a rule by the available room for grates. As most types of boilers will make dry steam when operated at several times their rated capacity, the use of oil fuel considerably reduces the outlay necessary for boiler plant and augments enormously the capacity to handle overloads.

The "Liquid Fuel Tests" conducted by the Navy Dept. demonstrated, in the words of the official report, an "ability to force boilers to extreme duty in case of emergency," and showed "that with the use of oil the forcing of a marine boiler should be much more readily accomplished than with the use of coal." In Test No. 8 on the Hohenstein water tube boiler, an evaporation equivalent to 16.7 lbs. of steam from and at 212° F. per hour per square foot of heating surface was maintained, nearly five times the usual commercial rating. The moisture in the steam was 1.2% and the boiler pressure 276 lbs. per square inch.

Of course, a high boiler efficiency is not to be expected at this rate of driving. The temperature in the chimney gases in the test just mentioned was 1017° F. and of the 19,481 British thermal units contained in each pound of oil, only 53.4% were absorbed by the boiler, while more than 36% escaped in the chimney gases.

This low efficiency can be remedied, however, by the installation of Green Fuel Economizers, which are more efficient in absorbing heat, square foot for square foot, than is boiler surface, because the temperature of their contents is lower and because an economizer's heating surface is, by automatic scrapers, kept free of the large quantity of soot deposited from oil.

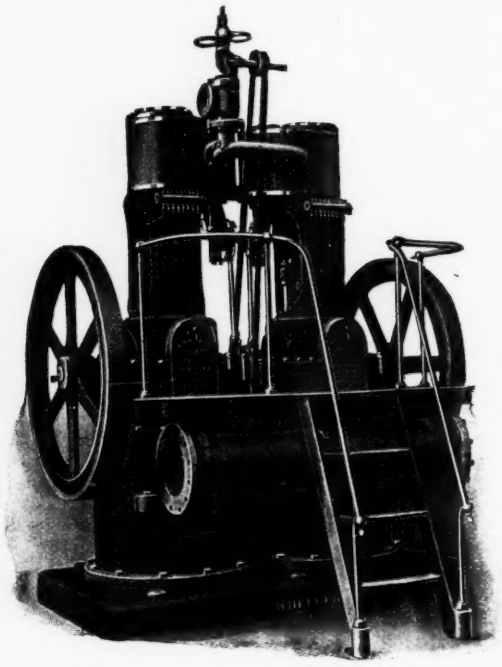
The Green Waste Heat Air Heater is also a valuable adjunct in burning oil because of its action as a regenerator in absorbing heat from the flue gases and imparting it to the air entering the furnace. This further increases the boiler efficiency, besides improving combustion, in regard to which the Naval report states: "The great benefit of heating the air necessary for combustion cannot be doubted."

Write for catalog "104 P."

The
Green Fuel Economizer Co.
MATTEAWAN, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal.

Engineers; Builders of Green's Fuel Economizers Fans, Blowers and Exhausters, Steam Air Heater Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines.



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10,000 AIR PUMPS

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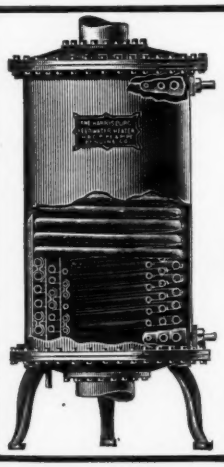

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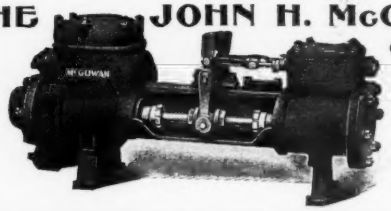

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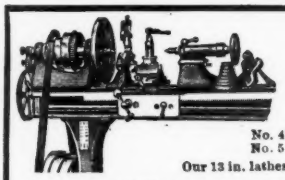

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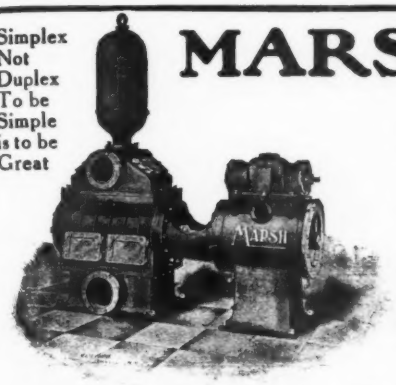

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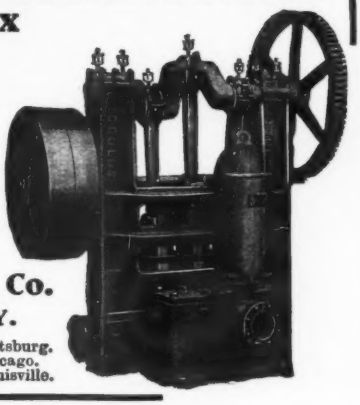

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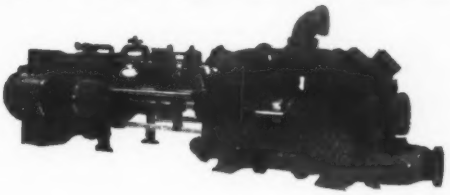

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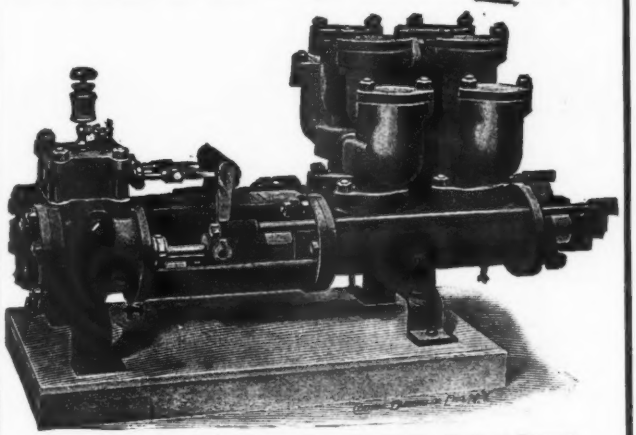

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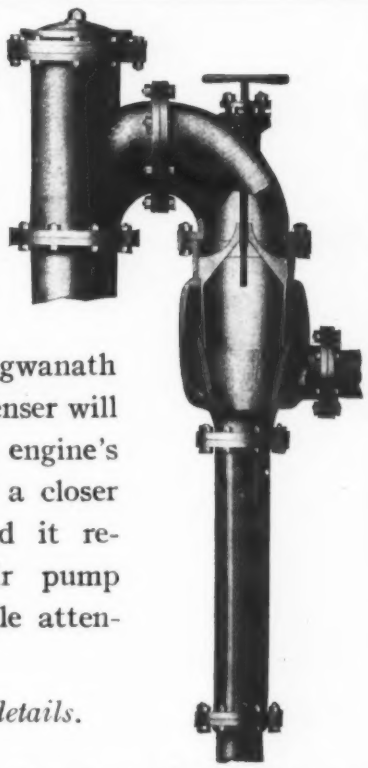

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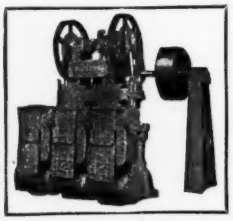

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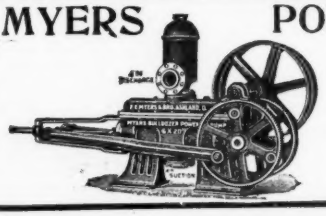

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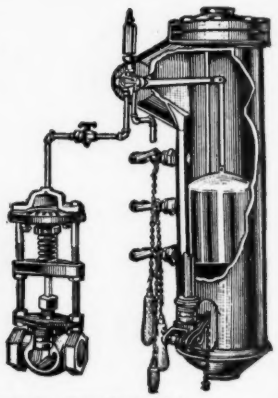

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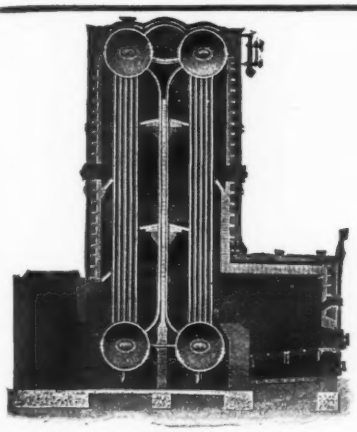

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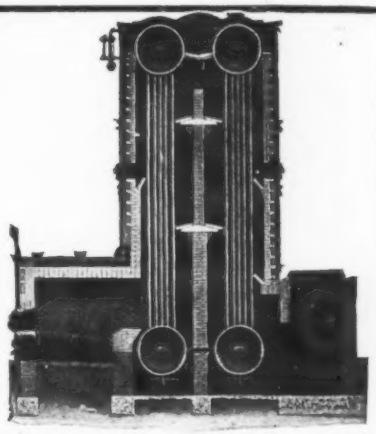

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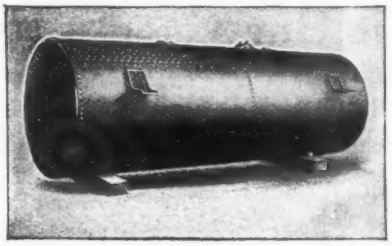

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Horizontal Tubular Steam Boilers
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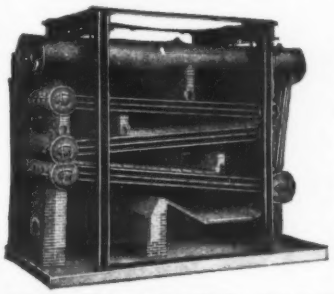

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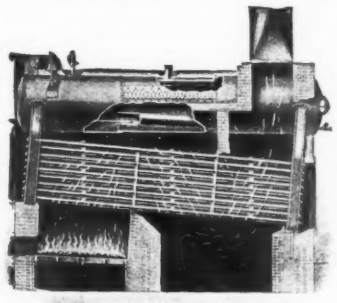

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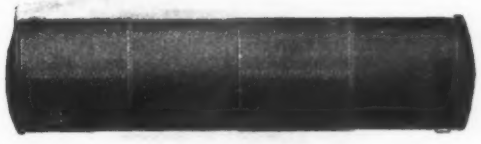

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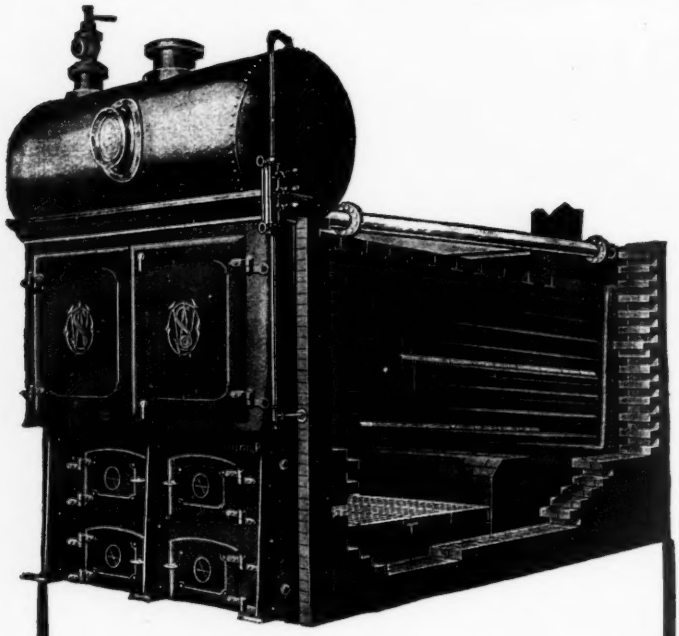

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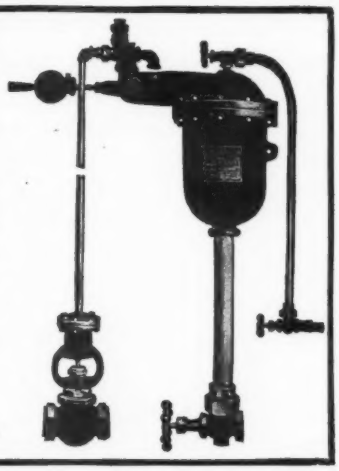

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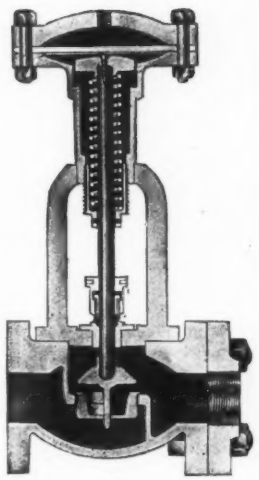

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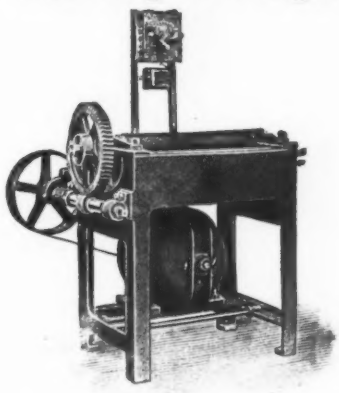

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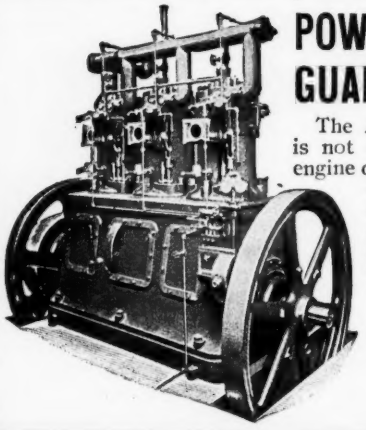

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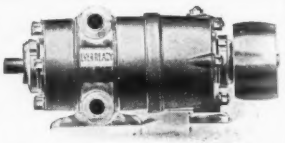

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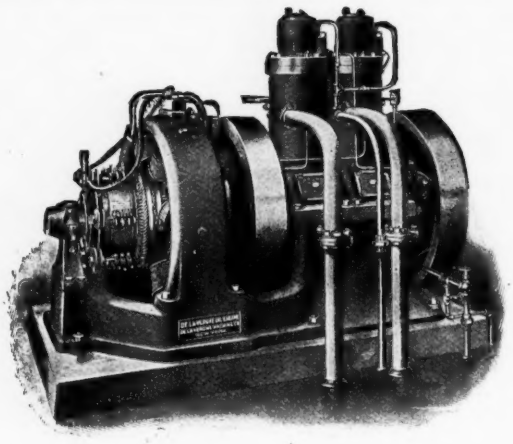

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are cheaper, simpler. more compact than any other motive power. 8 H. P. hours per gallon of cheap oil.

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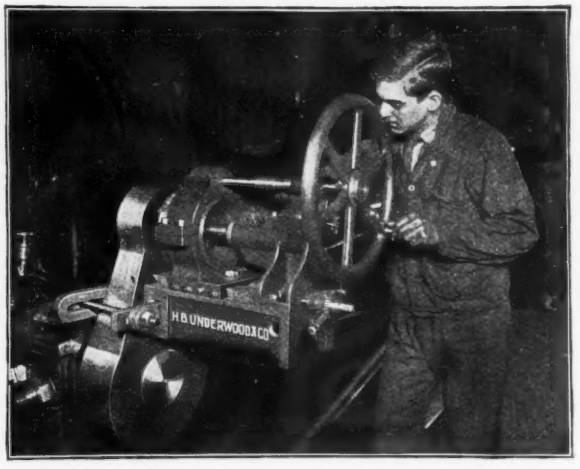
The "De La Vergne" Vertical two-Cycle 4 to 25 H. P.
"Hornsby-Akroyd" Horizontal Four-Cycle 2 1-2 to 250 H. P.

DE LA VERGNE MACHINE CO.

Foot East 138th Street, NEW YORK.



Wire For Us And We'll Repair For You

Any sort of engine repairs quickly, cheaply and satisfactorily done in your own plant without breaking connections. "Useful Hints P" will be sent to engineers upon request.

Ammonia Cylinders Indicated.

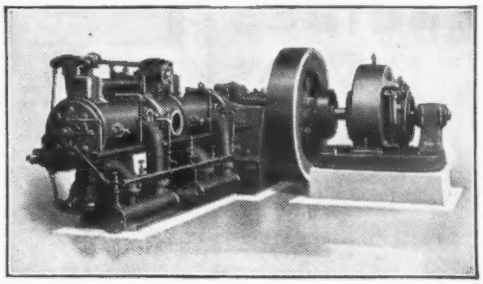
H. B. UNDERWOOD & CO.,
ESTABLISHED 1870.
1021 Hamilton Street, Philadelphia, Pa.

Three-tenths of a cent per horsepower hour will operate a DuBois Gas Engine.

We guarantee these engines to develope full power, to prove cool running and easily governed.

They operate on Natural or City Gas, Gasolene or Producer Gas.

Catalog "G."



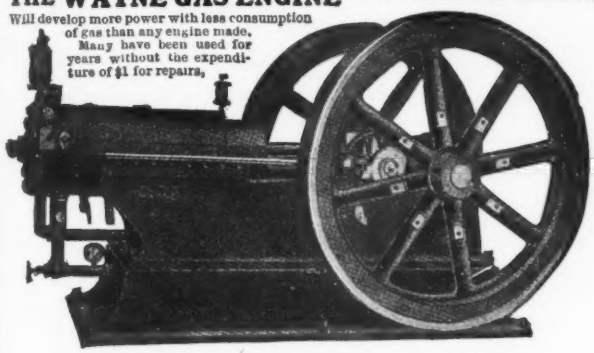
DuBois Gas Engines
"The Improved Type"

Established 1877

DuBois Iron Works

805 Brady St.
DuBois, Pa.

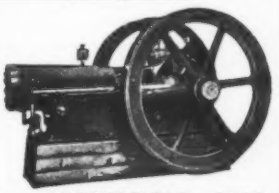
THE WAYNE GAS ENGINE Gas Producers from 35 H. P. up,
Will develop more power with less consumption of gas than any engine made. Many have been used for years without the expenditure of $1 for repairs,



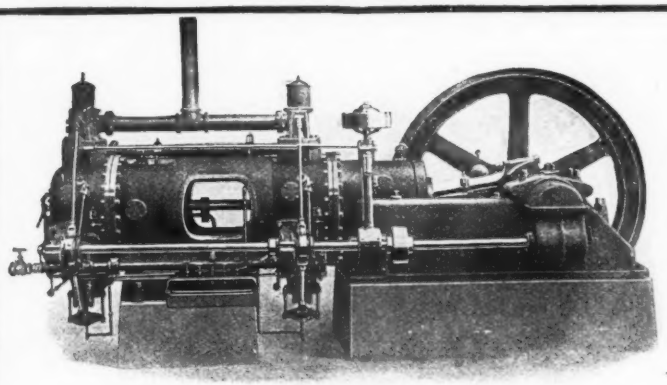
Each engine covered by a positive guarantee. Send for Catalog
The Fort Wayne Foundry and Machine Co., Fort Wayne, Ind.
New York Office: 100 BROADWAY,

FOOS GAS AND GASOLINE **ENGINES**

HAVE WIPE SPARK IGNITER, positive acting and self cleaning.
VERTICAL VALVES, mechanically operated, admit fuel charge into cylinder at atmospheric pressure.
CENTER-LINE COUNTERBALANCING increases the efficiency and decreases the fuel bills.
ACCESSIBLE DESIGN makes it a simple matter to keep Foos Engines properly adjusted.



Get Catalog K.
THE FOOS GAS ENGINE CO., SPRINGFIELD, OHIO.



WARREN GAS ENGINES
Horizontal and Vertical
Types up to 700 H. P.
NOT AN EXPERIMENT
Economy and Reliability Have Been Demonstrated by Actual Service
FULLY GUARANTEED
For All Street Railway, Electric Light and Power Requirements
STRUTHERS-WELLS COMPANY,
WARREN, PENNA.

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IF YOU CONTEMPLATE INSTALLING GAS POWER

write for full descriptive particulars concerning the Riverside engine and our comprehensive guaranty.

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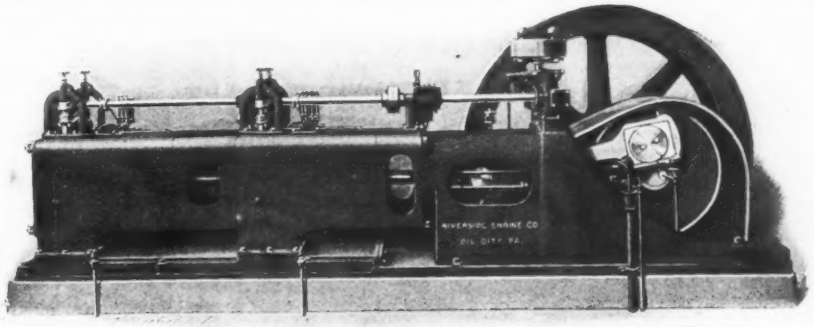


Riverside Heavy Duty Single Acting Tandem Gas Engine (Class C)

SHEPHERD ENGINES

Built with liberal allowance of metal in the **Bed** and **Frame.** Of course it costs a trifle more, but the increased durability makes it well worth while.

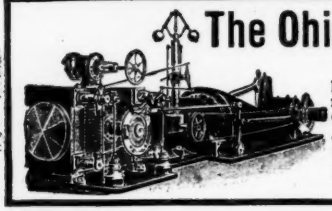
SHEPHERD ENGINEERING CO., Williamsport, Pa.

YOU CAN DEPEND ON NORTHERN APPARATUS ALWAYS.

Our machines operate constantly—sometimes twenty-four hours a day for years—under the severest possible operating conditions. Northern equipments endure in moist or dusty localities. They give constant, economical power and light ¶Whether your service is severe or easy you will find Northern machines well suited to your work. At any rate you ought to investigate this to prove that we are right or wrong. Get Bulletin 838 and tell us what you want to do with electric power. 895

NORTHERN ELECTRICAL MFG. CO., Madison, Wis., U.S.A.

Standard and Special Electrical Machinery.



The Ohio Corliss Engine

For hard work, heavy loads and high-speed, the Ohio shows close regulation and runs smoothly and quietly.

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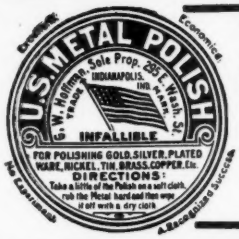
Est. 1840. ZANESVILLE, OHIO



THE ONLY METAL POLISH

that works quick and easy and keeps its lustre. Holds old trade and makes new. IT DOES NOT DETERIORATE. Established 16 years.

3-Ounce Box for 10 cts. 5-Pound Pails, $1.00

Sold by Agents and Dealers all over the world. Ask or write for Free samples. Highest Award, Chicago, '93; St. Louis, '04.

GEO. W. HOFFMAN, Expert Polish Maker,

295 E. Washington St., INDIANAPOLIS, IND.

Branches—New York, Chicago, San Francisco.

The overload capacity of **C-W** electric generators makes them popular with the engineer. In emergencies they do better than is expected of them. Bulletin 80M describes our D. C. machines.

CROCKER-WHEELER COMPANY

Ampere, N. J.

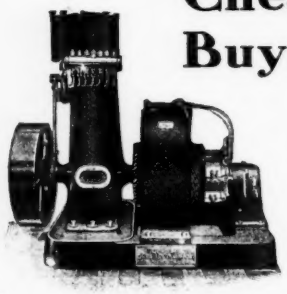
A Different And Better Bearing Metal

The Stage Coach used to be the thing—until the Locomotive came along. So did ordinary babbit—until "The Reeves" Bearing Metal showed engineers the way to get better results on all factory and machinery bearings. It's worth every cent of its price: 25 cents a pound. If your dealer hasn't got it, write to us for a 50 lb. trial box. Test is the best proof.

Reeves Pulley Company

Columbus, Indiana

Cheaper Than Buying Current



In any plant where a steam boiler is operated one of our generating sets will furnish current more cheaply than it can be bought from the mains. Circular?

Engberg's Electric & Mechanical Works

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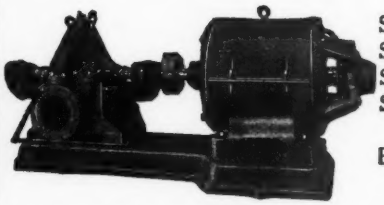
DE LAVAL



Steam Turbine Motors
Steam Turbine Dynamos
Steam Turbine Blowers
Steam Turbine Centrifugal Pumps
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De Laval D. C. Motor-Driven Pump.

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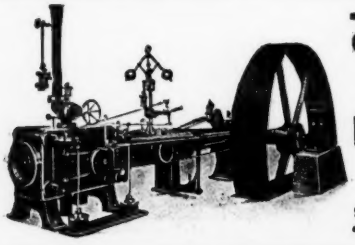

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Refrigerating and Ice Making Machinery

THE VILTER MFG. CO.

910 Clinton St., Milwaukee, Wis.

The Allan Metal for Pistons and Bearings.

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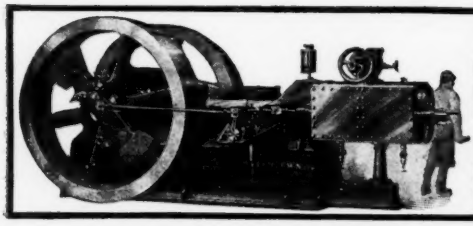

Good Engines for every power purpose. Ask for Catalog.

Watertown Engine Co.,

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ALBERGER TANDEM GAS ENGINES

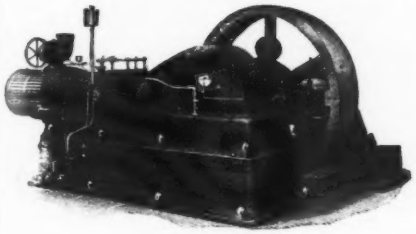
ACCURATE REGULATION FOR ELECTRIC SERVICE-AUTOMATIC CUT-OFF AND RITES FLY-WHEEL GOVERNOR

A.H. ALBERGER COMPANY

45 TO 600 H.P. USING NATURAL GAS
35 TO 500 H.P. USING PRODUCER GAS

695-697 ELLICOTT SQ
BUFFALO, N.Y.

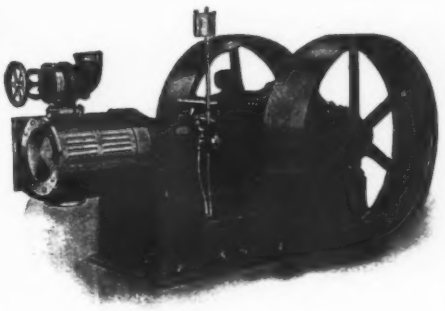
Skinner Engines



SIDE CRANK TYPE

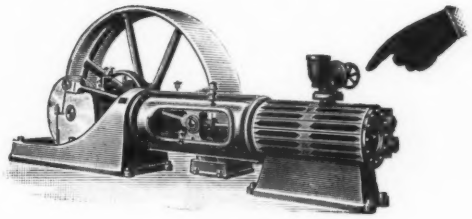
CENTER CRANK
SIDE CRANK
SINGLE and FOUR VALVE

Skinner Engine Co.,
Erie, Pa.



CENTER CRANK TYPE

Fitchburg Facts



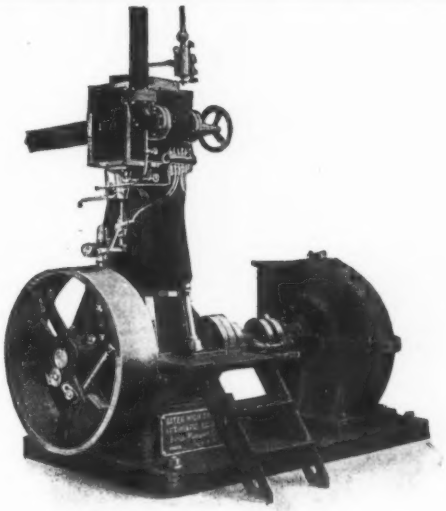
¶ One hour per year will keep a Fitchburg steam tight for 20 years

¶ Its perfectly balanced piston valves defy superheat and great pressure.

¶ Positive adjustment to compensate for wear. Write for other details.

Fitchburg Steam Engine Co.
Fitchburg, Mass.

E. H. Ludeman & Co., 165 Broadway, New York. H. J. Gebhardt, 1419 Fisher Building, Chicago. Geo. H. Conner, 509 Mutual Life Building, Phila., Pa. W. C. Teas, Chattanooga, Tennessee. Western Trading Co., Francisco.



Bates Vertical Automatic High Speed Engine for connection to Pumps. Especially adapted for

WATER WORKS, IRRIGATION

and other places where it is desired to move a large volume of water at small expense.

CATALOG FOR THE ASKING.

BATES MACHINE CO., Joliet, Ill.

Lammert & Mann

Engineers and Machinists

157 S. Jefferson Street, CHICAGO

WE MAKE A SPECIALTY OF

Corliss Engine Repairs. Engines Indicated.
General Jobbing. Repairing Engines.
Pumps, etc., all kinds Special Machinery.
Pulleys, Hangers, Shafting, etc. Oil Dash Pots.

York Manufacturing Co.

York, Pennsylvania

We manufacture all machinery and parts needed to equip a complete Ice or Refrigerating plant—

Machines, Condensers, Tanks, Cans, Coolers, Piping, Boilers and Ammonia Fittings.

of all kinds. We employ over 1,250 men in the manufacture of Ice and Refrigerating Machinery exclusively. Catalogue sent upon request.

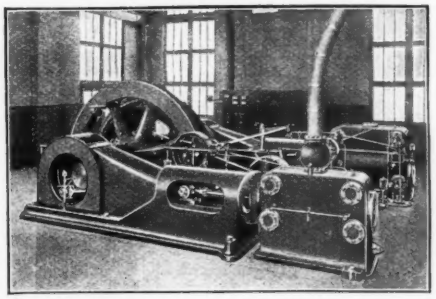
SOUTHWARK FOUNDRY AND MACHINE CO.

PHILADELPHIA, PA.

Our type of BLOWING ENGINES for Blast Furnaces and Bessemer Steel Works is largely used in the United States and Europe.

Built of vertical and horizontal pattern; simple and compound steam ends; and air cylinders fitted with our patented grid-iron valves which make it possible to operate at higher speeds than with the usual form of air valve.

CATALOG UPON APPLICATION.



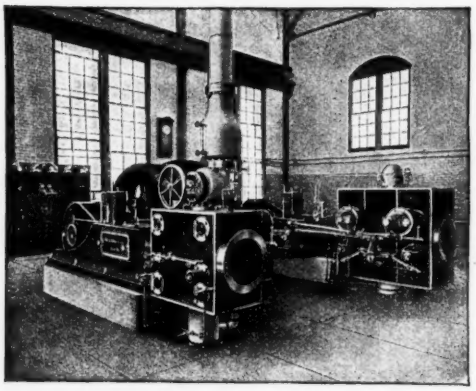
Rice & Sargent Corliss Engines

The illustration shows a 400 K.W. Rice & Sargent engine running 150 R.P.M.

DESIGNED AND BUILT BY

PROVIDENCE ENGINEERING WORKS

Main Office and Works PROVIDENCE, R. I.



The Ball Engine Co., Erie, Pa.

"BALLWOOD" Engines

may cost a little more than the ordinary kind, but their higher and more permanent efficiency and economy make them far superior to any others. They save and satisfy.

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THE BALL & WOOD CO.,

ELIZABETHPORT, N. J.

New York Sales Office, Cortlandt Building, 30 Church Street

MAKERS OF BALLWOOD FLANGES

"ERIECO"

The engine that guarantees efficient and economical operation more days to a year and more years to an engine than any other.

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Erie Mfg. & Supply Co.

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The Remarkable Growth

in the demand for Cooper Corliss Engines has, within the last few years, compelled us to more than double our manufacturing facilities. Ask for particulars.

THE C. & G. COOPER CO.

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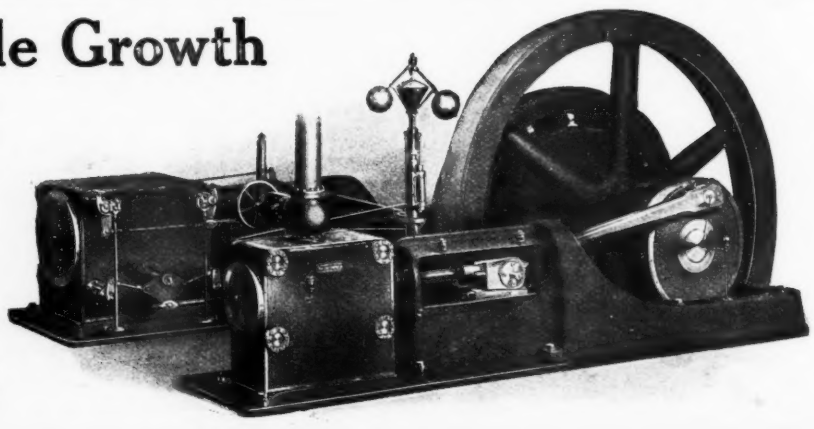
New York, 918 Bowling Green Bldg.; Boston, 411 Weld Bldg.; Pittsburg, 604 Frick Bldg.; Philadelphia, Drexel Bldg.; Atlanta, 310 Candler Bldg.; Charlotte, N. C., Court House Square; Chicago, 1539 First Nat'l Bank Building.



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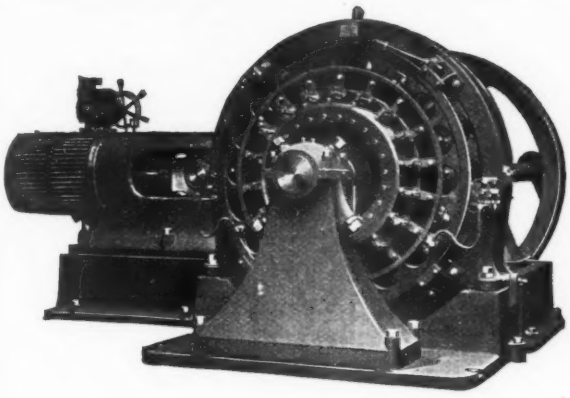
CHESTER, PENNSYLVANIA.

CORLISS STEAM ENGINES

Manufacturers

POWER PLANTS BOILERS



Built Expressly To Run Together

Thompson-Ryan Dynamos and McEwen Engines will generate more current with less attention, less repair, and less power than any other generating set. Write.

Ridgway Dynamo & Engine Co.

Works, Ridgway, Pa., U. S. A.

BUCKEYE ENGINE COMPANY,

SALEM, OHIO

BUILDERS OF HIGH CLASS

STEAM AND GAS ENGINES

HIGH IN DUTY, SUPERIOR IN REGULATION

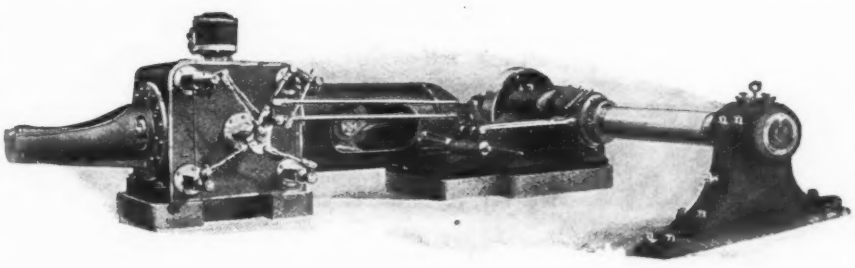
AND

ABSOLUTELY RELIABLE

CORRESPOND WITH US BEFORE PURCHASING

CATALOGS ON APPLICATION

THE CLARK HEAVY DUTY CORLISS ENGINE



Valve travel never varies. No other Corliss engine has this advantage. Result perfect valve setts. Cuts off at all loads. As quick as the releasing gear. Heavy duty bed with bored guide. Main bearings half diameter of pistons. Length in proportion. Outboard bearing pedestal type. Adjustable in all directions. And self-oiling. Shaft swelled between bearings. Wheels above ten feet in diameter in halves. All wheels have split hubs. Our engines are unequaled for low steam consumption, perfect regulation, long life, nominal repairs, beauty of design. Perfect distribution of metal, high class material. Perfect workmanship

THE CLARK BROS. CO., - Belmont, N. Y.

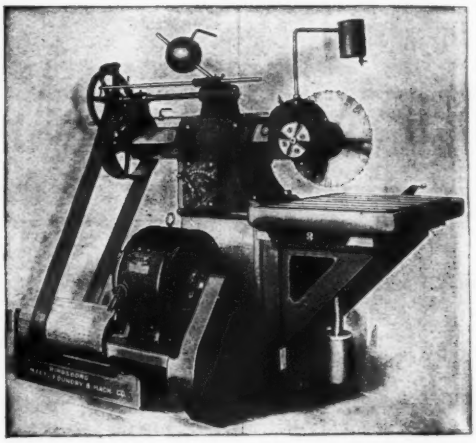
Westinghouse

Motor-Drive

Where speed changes are necessary

use a Westinghouse variable-speed motor having characteristics enabling its speed to be adapted to exactly the conditions required by the work in hand. The adjustment of speed is accomplished easily, economically, effectively and with positiveness.

Ask for Booklet 23.



Westinghouse Motor Driving Wagner Saw with Morse Silent Running Chain.

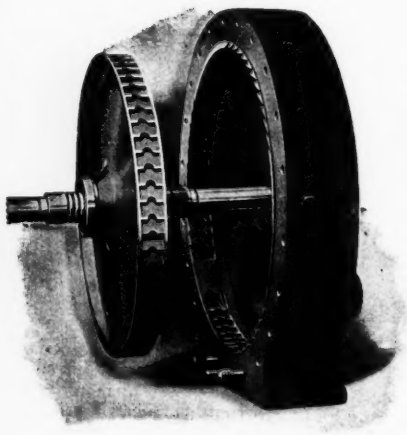
Westinghouse Electric & Mfg. Co.

Atlanta · Baltimore · Boston · Buffalo · Chicago · Cincinnati · Cleveland · Dallas · Denver · Detroit · Kansas City · Los Angeles · Minneapolis · New Orleans · New York · Philadelphia · Pittsburg · St. Louis · Salt Lake City · San Francisco · Seattle · Syracuse

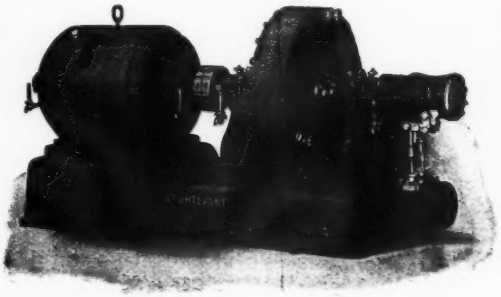
Canada : Canadian Westinghouse Co., Ltd., Hamilton, Ontario. México : G. & O. Braniff & Co., City of Mexico.

STURTEVANT STEAM TURBINE

For Driving Fans, Generators, etc.
Buckets cut in solid steel.
No internal lubrication.



Can be placed on ordinary floor.



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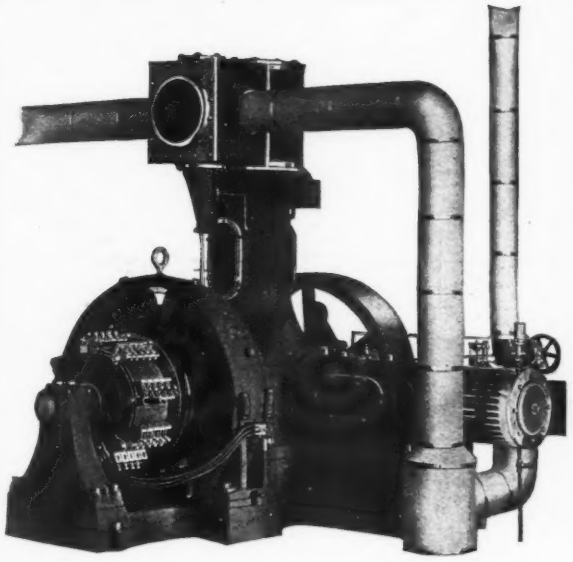
B. F. STURTEVANT CO., Boston, Mass.

General Office and Works, Hyde Park, Mass.

NEW YORK PHILADELPHIA CHICAGO CINCINNATI LONDON

Designers and Builders of Heating, Ventilating, Drying and Mechanical Draft Apparatus; Fan Blowers and Exhausters, Rotary Blowers and Exhausters; Steam Engines, Electric Motors and Generating Sets; Pneumatic Separators, Fuel Economizers, Forges, Exhaust Heads, Steam Traps, Steam Turbines, etc. 696



The Engine For Driving Alternators

Where two alternating current electrical generators are run in parallel, their efficiency and regulation depend upon other things than the generators themselves. If the two generators are driven by engines of different types, or even by two ordinary engines of the same size and type but with the piston not moving in unison, cross-currents are set up, which waste power, reduce the capacity of the generator and interfere with the voltage regulation.

The desirable condition, therefore, in alternator driving is to have the turning moment of the prime mover absolutely uniform throughout a revolution. This can be attained, together with perfect conditions for balancing and high steam economy and in the least possible space, by setting the cylinders at right angles, so that the greatest effort of the one occurs at the time of the least effort of the other, resulting in a practically uniform turning moment throughout the revolution.

This is one of the advantages of the American-Ball Compound Engine. Other advantages realized at the same time are smooth, quiet running, small foundations and floor space and excellent regulation.

Write for our Treatise on Compounds.

American Engine Co.,
22 Raritan Ave., Bound Brook, N. J.

14

Small Curtis Turbine Generators

The simplicity of the Curtis Turbine is not alone a feature of construction. It also contributes to valuable operating advantages. There are no internal wearing parts to cause a decrease in efficiency, after long periods of operation. Compare the view below of the working parts of the turbine with the corresponding parts of a steam engine and calculate the expense of piston packing, reboring cylinders, valve grinding and bearing linings for an engine which are avoided in the Curtis Turbine.

Wheels and shaft of 75 kilowatt Curtis Turbine in position in lower half of wheel casing

And remember that no injury is done if the Curtis Turbine is flooded with water while in operation, and that it may be brought up to speed ready to carry the load almost instantly without the warming-up, draining, etc., customary with the reciprocating steam engine.
If you need more power tell us what you have and we will tell you more about these small turbine sets.

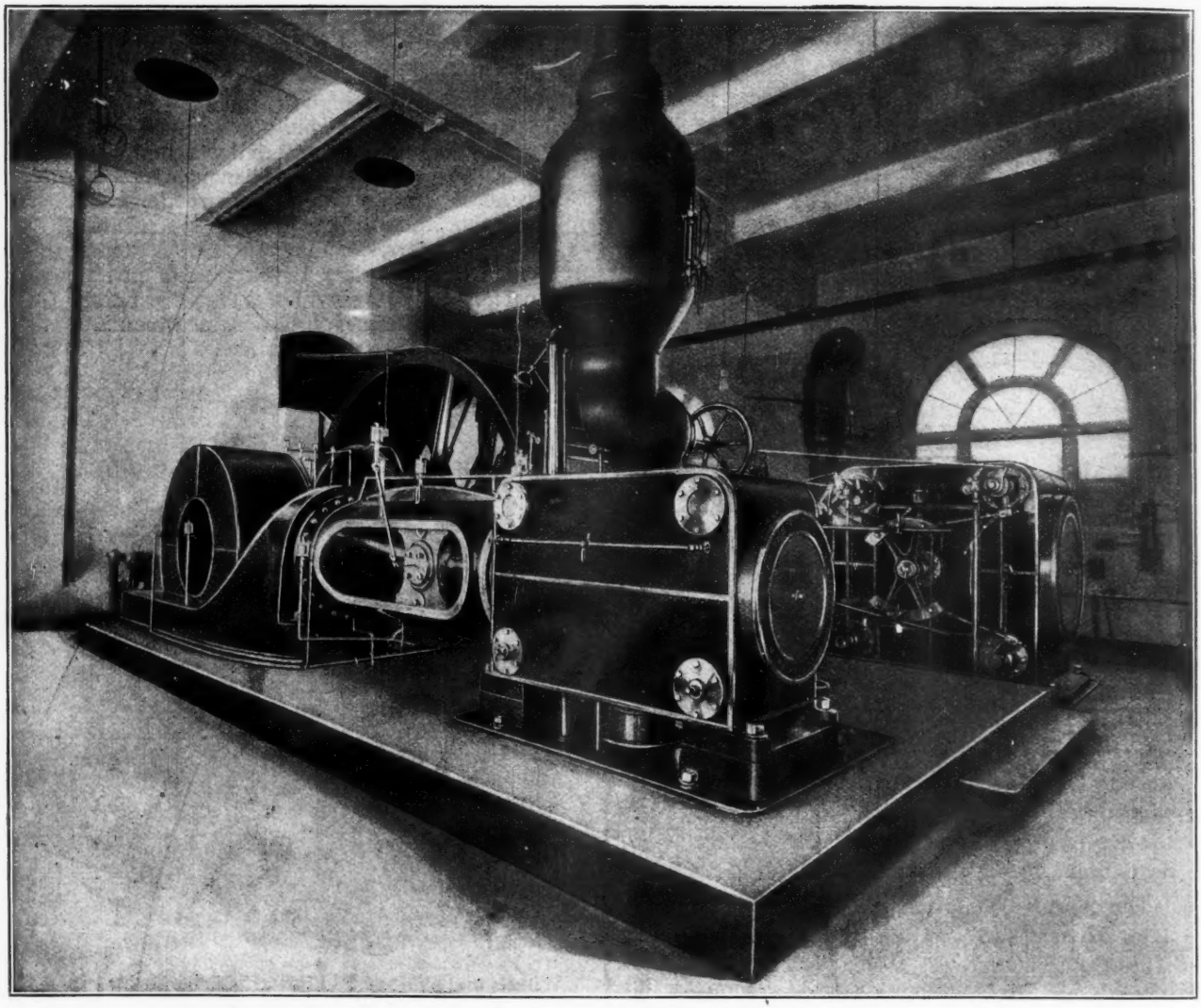
General Electric Company

Principal Office: SCHENECTADY, N. Y.

New York Office: 30 Church St.
Sales Offices in all large cities.

1790

Twin City CORLISS ENGINE



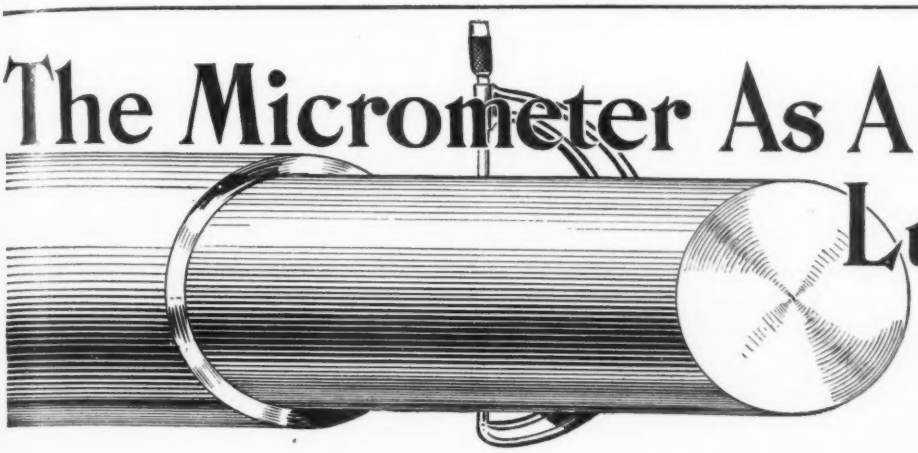
1,500 H. P. Cross Compound Twin City Corliss Engine—Rope Drive—just Installed by us in a New Flour Mill in Minneapolis. Fly Wheel 18 ft. Diameter, Grooved for 24 2-in. Ropes.

When considering the purchase of a new engine, do not fail to have a talk with one of our Engineers, who will gladly call upon you if requested. Owning one Twin City you will never be satisfied with any other.

Brochure No. 101 sent upon application.

MINNEAPOLIS STEEL AND MACHINERY CO MINNEAPOLIS

The Micrometer As A Test For Lubricants



Has Clearly Proved That

Keystone Grease

Preserves The Size Of The Shaft By Keeping Out Grit And Dust

Applied in our Grease Cups, Keystone forms a seal on outer edge of bearings that prevents the entrance of dust and grit. Thus the shaft runs in its bearing without friction and with nothing to wear it away. Keystone Grease has a body which spreads over both surfaces of the metal, allowing shaft to revolve freely but at no place to come into actual contact with bearings.

Friction Is Annihilated

and there are none of the wastes common to the use of oil. One pound of Keystone Grease will last longer and lubricate better than 3 to 4 pounds of any other grease or 4 to 6 gallons of any oil.

KEYSTONE
TRADE MARK
REGISTERED U.S. PAT. OFF.

See our advertisement on page three.

KEYSTONE LUBRICATING COMPANY

Department B.

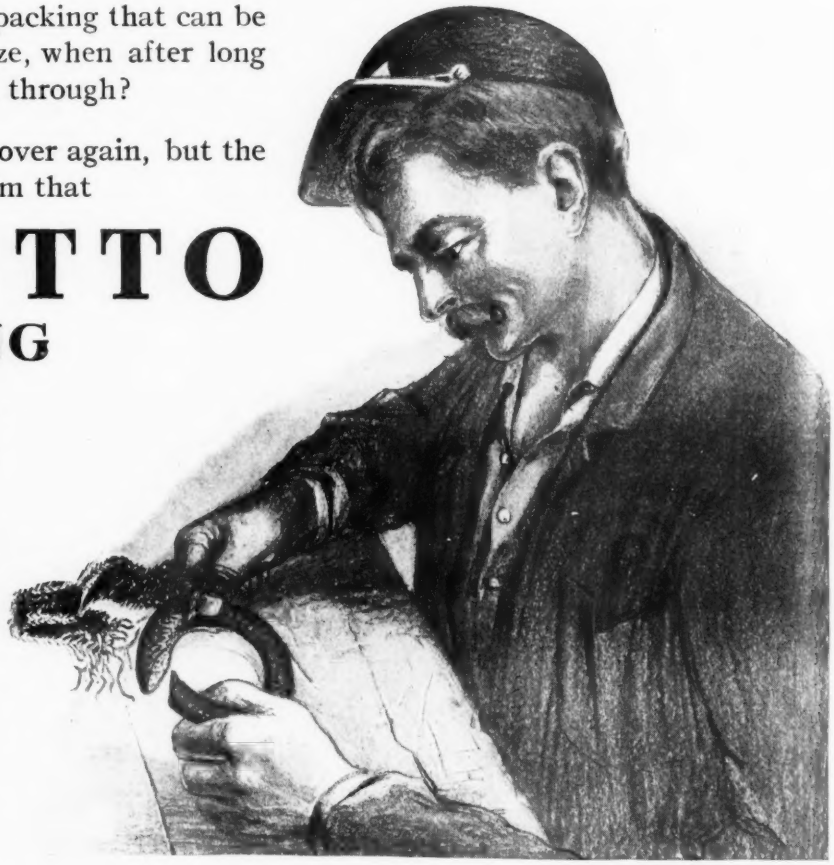
PHILADELPHIA, PA.

New England Office, 10 Oliver St., Boston, Mass.
Chicago Office, 1210 Tacoma Bldg.
Northwestern Office and Warehouse, 502 McPhee Bldg., Denver, Col.
New York City Office, 96 Warren Street.
Southern Office, 610 Chartres St., New Orleans, La.
San Francisco Office and Warehouse, 268 Market Street.

WHAT do you think of a packing that can be used over as a smaller size, when after long service the outside cover is worn through?

You may not wish to use it over again, but the fact that you can proves our claim that

PALMETTO
PACKING



because of our special process of manufacture remains soft and pliable during its entire life.

Twist (on 1 lb. spools) for small stems.

Braided, Rd and Sq. (in 5-lb. boxes) for large stems.

Send for free working samples.

Greene, Tweed & Co.

Sole Manufacturers

109 Duane St. New York

THE BRISTOL COMPANY

SPECIALISTS IN

Recording Instruments

FOR

PRESSURE
TEMPERATURE
AND
ELECTRICITY

Wm. H. Bristol Recording Shunt Ammeters And Bristol's Recording Pressure And Vacuum Gauges For Power Plants.

The BRISTOL CO., Waterbury, Conn.

BRANCH OFFICES

114 Liberty St., NEW YORK. 753 Monadnock Building, CHICAGO.

STARRETT
SPEED INDICATORS
OR REVOLUTION COUNTERS

No. 104.—This indicator may be run at the highest speed required without heating. The working parts are encased. Dial has two rows of figures, reading right or left as the shaft may run. Steel pointed spindle with rubber tips for both pointed and centered shafts. The (O) mark may be instantly set at starting point.

Price, Postpaid, $1.00

No. 107.—Has all the good points of the above, and in addition has a hard rubber handle for insulation when used on electrical machinery. It also automatically registers the number of revolutions up to 5,000, thus relieving the mind from keeping count.

Price, Postpaid, $3.00

Send for FREE Catalogue, No. 17-R, of Fine Tools.

The L. S. Starrett Co.

Athol, Mass., U. S. A.